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PRODUCT ENGINEERING

SEPTEMBER
1935

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Progress in Machine Tool Design—Circuits for Hydraulic Operation—Machine Drives for Variable Speed—Effects of Color—Special Anti-Friction Bearings—Finishing Schedules

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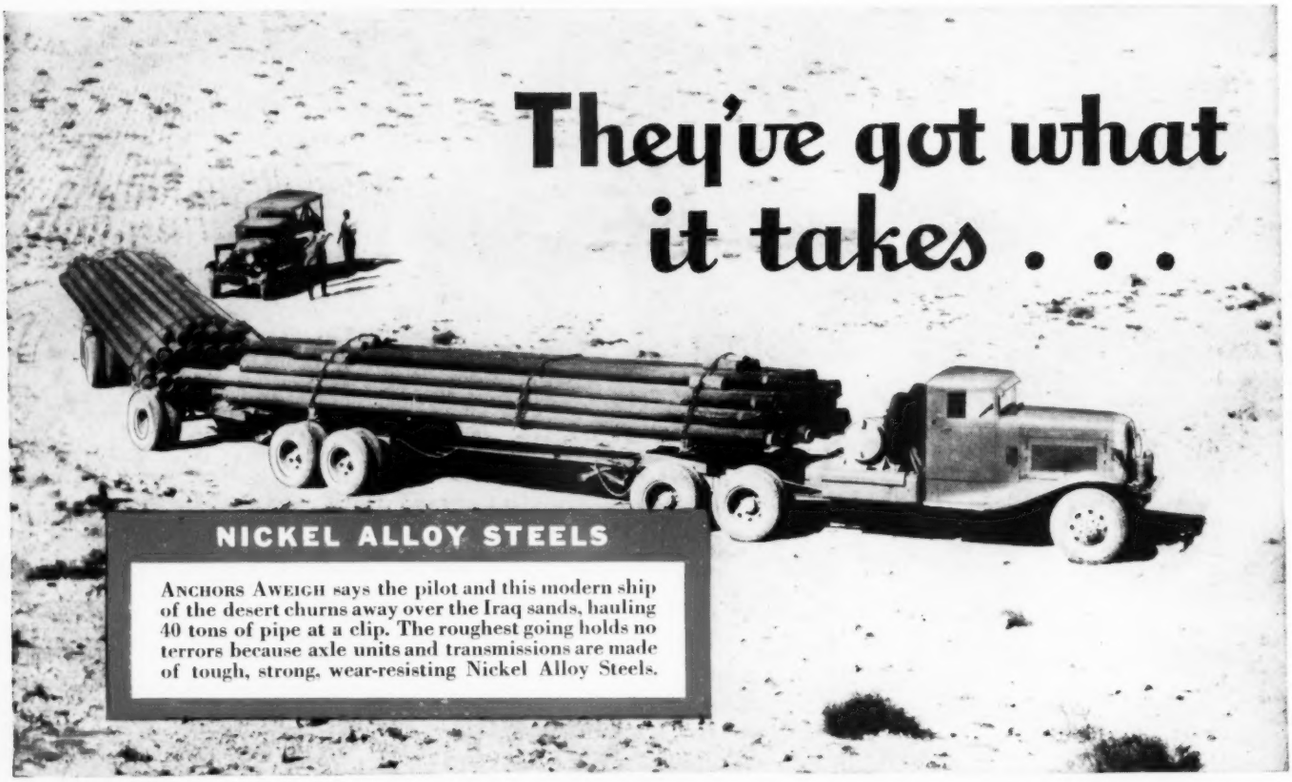
Mechanical Design • Product Development

McGRAW-HILL PUBLISHING COMPANY, INC.

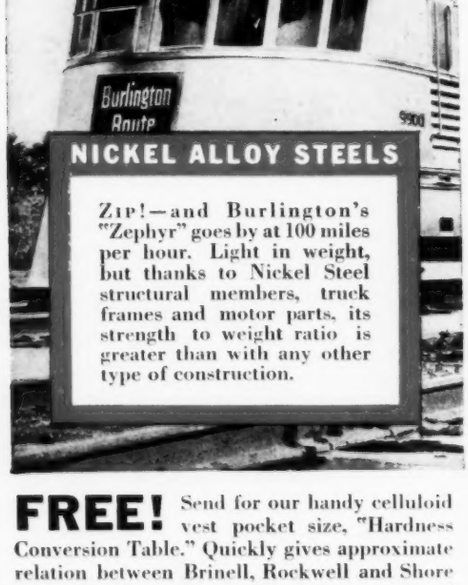


They've got what it takes . . .

NICKEL ALLOY STEELS

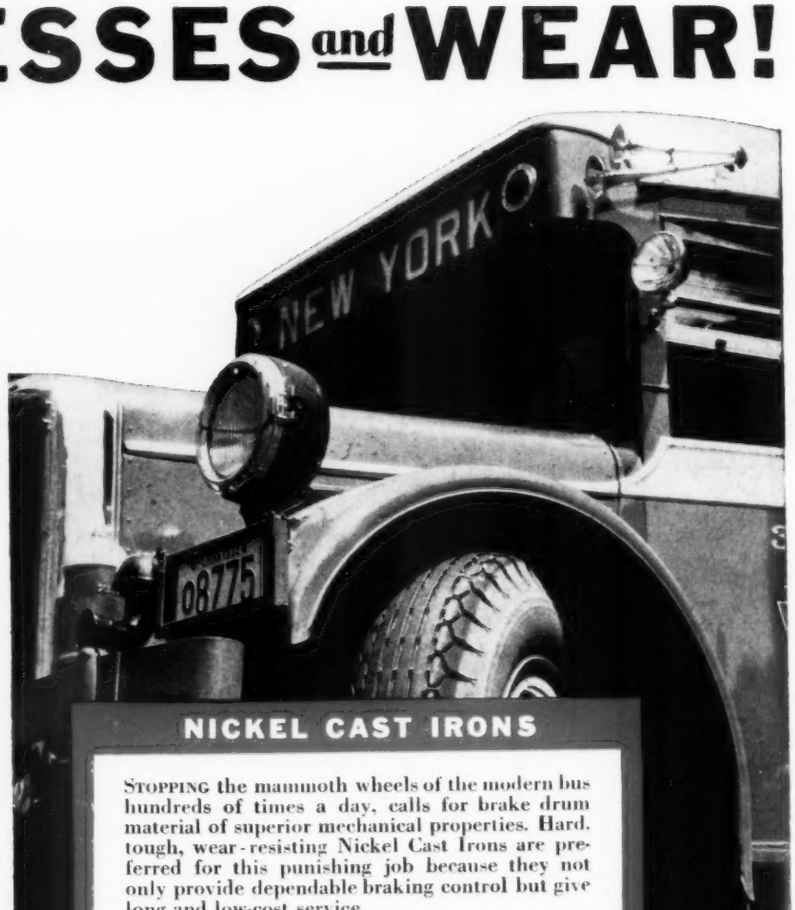
ANCHORS AWEIGH says the pilot and this modern ship of the desert churns away over the Iraq sands, hauling 40 tons of pipe at a clip. The roughest going holds no terrors because axle units and transmissions are made of tough, strong, wear-resisting Nickel Alloy Steels.

to win against STRESSES and WEAR!



NICKEL ALLOY STEELS

ZIP!—and Burlington's "Zephyr" goes by at 100 miles per hour. Light in weight, but thanks to Nickel Steel structural members, truck frames and motor parts, its strength to weight ratio is greater than with any other type of construction.



NICKEL CAST IRONS

STOPPING the mammoth wheels of the modern bus hundreds of times a day, calls for brake drum material of superior mechanical properties. Hard, tough, wear-resisting Nickel Cast Irons are preferred for this punishing job because they not only provide dependable braking control but give long and low-cost service.

FREE! Send for our handy celluloid vest pocket size, "Hardness Conversion Table." Quickly gives approximate relation between Brinell, Rockwell and Shore hardness values and corresponding strengths of Nickel Alloy Steels. Address Dept. I-5.

THE INTERNATIONAL NICKEL COMPANY, INC., 67 WALL ST., NEW YORK, N. Y.

PRODUCT ENGINEERING

VOLUME 6 NUMBER 9

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Next Month

In the limelight next month will be the National Metal Exposition and Congress and the fall meeting of the American Welding Society, to be held jointly at Chicago, Sept. 30 to Oct. 4.

In tune with this, October *P.E.* will include articles on composite cast and welded construction, alloys for die-castings, typical alloy steels for gears and recent developments in bearing alloys. Also an article on lubrication and, of course, a four-page article by Howard Ketcham printed in color.

November Issue

Many of our readers have already heard about it. In November we publish the report of our Fourth Annual Product Development Survey. This year we are extending this survey and changing the presentation to make it easier to use for reference.

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Intimate Correspondence

Photo Electric Controls

PRODUCT ENGINEERING
NEW YORK

Have you published in *Product Engineering*, or can you refer us to other literature, giving essential information on the design of a small high-speed clutch to be actuated by a photo-electric cell? —E.S.R.
Rochester, N. Y.

IN the October, 1933, number, on page 380, the article "How Photo-Electric Controls are Applied," describes on the third page of the article a high-speed continuous synchronizing device for use on bread wrapping machines. Figs. 9 and 10 in this article also describe the device.

High Pressure and Low Speed

PRODUCT ENGINEERING
NEW YORK

There is one problem I look for—but find nothing. The lubrication of very slow running bearings, or those which may stand still for months and must then move frictionless at any temperature (—30 to +120 F.). I refer principally to outdoor and portable instruments, where oil reservoirs are not practicable and exposed oil must be avoided on account of dust. —W.L.E.
Troy, N. Y.

HERE'S a problem that undoubtedly has caused lots of grief. Oilless and graphited bronze are being used on a number of such applications. Have any of our readers new data on this problem?

Nothing Is Ever Perfect

PRODUCT ENGINEERING
NEW YORK

Your publication always has something new and of interest in each issue. This time, to me it is Ketcham's article on getting the right color. But, it is not clear whether this is an ad by Ketcham or whether he is on your editorial staff. The article is beautifully printed, but the author has completely omitted some very popular composite colors that are used on many cars today. The reason for that is not clear. —H.W.
Cleveland, Ohio

FOR the present Mr. Ketcham is a regular contributor to *Product Engineering*. Because he is a recognized authority on color selection, editor of the *Automobile Color Index*, and director of the Duco Color Advisory Board, we went after Mr. Ketcham and finally succeeded in making arrangements with him to write this series for *Product Engineering*. We are pleased to know that the article reflects credit upon Mr. Ketcham.

The complete omission of some of the very popular composite colors that are used on many cars today can only be explained by the fact that even in a four-page article it is impossible to cover all of the matters relating to colors as applied to even only a single group of products. Of course, the primary purpose of this series of articles is to set forth the basic scientific facts relative to color selection rather than to attempt to give a complete exposition of the application of color to any one product.

Long Remembered

PRODUCT ENGINEERING
NEW YORK

I wish to take this opportunity to compliment you on the excellent article "Simplified Velocity and Force Diagrams" in the April issue of *Product Engineering* and trust you will print more articles along this line. —A.L.M.
Yorkville, Ohio

EVIDENTLY A.L.M. must have been much impressed with that article to have kept it in mind such a long time. It speaks well for the author of the article G. B. Karelitz.

Yes, we will have more such articles. Just now two of our contributors are working on series of articles of the same general character.

Color in Household Devices

PRODUCT ENGINEERING
NEW YORK

I was much interested in the Ketcham article but not being in the automobile business, the examples he gave are not in my line. Will Mr. Ketcham have an article on color as applied to such things as kitchen equipment and electric devices for the home? —P.A.S.
Cincinnati, Ohio

WE want to emphasize that in this series of articles Mr. Ketcham is presenting the fundamental principles relating to color. In each article he illustrates the principles by their application to some particular line of products. But the principles have quite general application.

In one of Mr. Ketcham's articles he will illustrate the principles by their application to household machinery and equipment.

More on Surface Qualities

PRODUCT ENGINEERING
NEW YORK

In your August issue there was a discussion regarding the "Designation of Surface Qualities," by Lieutenant - Commander Robert J. Walker. I hope that you will have more discussions on this same question of surface qualities and finishes as no doubt many companies have the same problem to deal with. —B.F.H.
New Freedom, Pa.

THE hope of B.F.H. will be realized in an early number of *Product Engineering*. This second article on the subject of surface finishes will deal primarily with the various methods for measuring the degree of smoothness of the finish.

Yours for the Asking

PRODUCT ENGINEERING
NEW YORK

If your willingness to supply clippings from *Product Engineering* extends to the very excellent color article appearing in the August, 1935 issue, we shall be pleased to receive two copies of it. —W.B.H.
West Orange, N. J.

WE suspected this and therefore had an extra run made of the article "Getting the Right Color" by Howard Ketcham. As long as they last, we will be glad to send copies of this insert for the asking.

What Does It Cost?

PRODUCT ENGINEERING
NEW YORK

As a suggestion, let us have some articles on costs of operations such as the cost of welding by gas and electricity. For example, the cost per foot for welding various beads. Also cost of patterns, forgings, etc. And articles on applied mechanics are always welcome. —G.L.T.
Pittsburgh, Pa.

THAT is a big order. We will gather some cost figures as suggested, but when it comes to cost of patterns and forgings it is almost impossible to give figures that will be generally applicable. There is too much variation in such costs.

As to applied mechanics, we have a series that will start early next year. It is being delayed because the author is proving equations by actual tests.

PRODUCT ENGINEERING

GEORGE F NORDENHOLT, *Editor*

McGRAW-HILL PUBLISHING CO., INC. SEPTEMBER 1935 VOLUME SIX, NUMBER NINE

As the Machine—So Is the Product

BE IT an automobile, typewriter, vacuum sweeper or any other machine, American buyers are demanding products that will be durable and trouble-free in operation. With reference to automobiles, this was clearly demonstrated by a recent survey conducted by General Motors. Dependability of performance and durability were ranked above everything else that automobile prospects demanded. There was not even a close second.

In every machine trouble-free operation and durability depend primarily on the dimensional accuracy and surface finish of the interacting mechanical parts. The first establishes the initial degree of perfection of operation; the second determines the trouble-free life of the machine. The ratio of the performance value of the machine to its price will be a measure of the value of the product as a salable article. On the other hand, performance being a reflection of the accuracy and finish of the parts, machining costs will be the final determining factor in the establishment of the performance value—price ratio.

Every engineer is capable of indicating close dimensional tolerances and specifying fine surface finishes. One of the ear marks of the novice designer is the abandon with which he jots down "plus or minus 0.0002 in." The mature designer will carefully weigh the cost of the machining operation against the sales value created thereby. And herein often lies a disheartening situation.

Cost of procuring a given dimensional accuracy and fine finish varies according to the age of the machine tools in the shop. Especially over the past decade, the developments in the machine tool industry have made possible more accurate finishes at less cost wherever modern machine tools are used. Even when compared with machines exhibited at the last Machine Tool Show in 1929, the changes in the design of the machine tools and comparisons of their production capabilities are striking. But there are many shops attempting to do 1935 machining operations on 1925 machine tools.

Every designer should know the production capabilities of available machine tools. A design executive can often point the way to a proper correlation between the requirements for manufacturing the design and the type of production equipment that would be most econonomical. This presupposes that the designing engineer is abreast of the latest developments in the machine tool industry.

At Cleveland, Ohio, September 11-21, will be held the National Machine Tool Show. Here will be seen the latest in machine tools of all kinds, welding equipment, accessories and shop equipment. On exhibition will be new models of machine tools, designed to take the fullest advtange of tungsten carbide cutting tools, machines that incorporate the latest in electric motors, automatic controls, hydraulic operations, new metals and alloys, welded construction and innumerable other features. Time spent in inspecting the exhibits and discussing their merits with the machine tool manufacturers' representatives will be well spent. Perhaps the strongest impression that the designing engineer will get at the Machine Tool Show will be the conviction of the futility of attempting to manufacture modern products with 1925 model machine tools.

Of course, many of the design features that will be found in the new machine tools that will be exhibited at Cleveland will have application in other fields of product design. But, undoubtedly of greatest value to the product designer is the opportunity of being brought up-to-date with reference to the performance ability of modern machine tools. Not only will he get new ideas of economical accuracy and production rates, but he will also be in a better position to argue the case for modern equipment for the manufacture of his modern designs.

SEE THE SHOW—GET UP-TO-DATE!

Six Years of Progress In Machine Tool Design

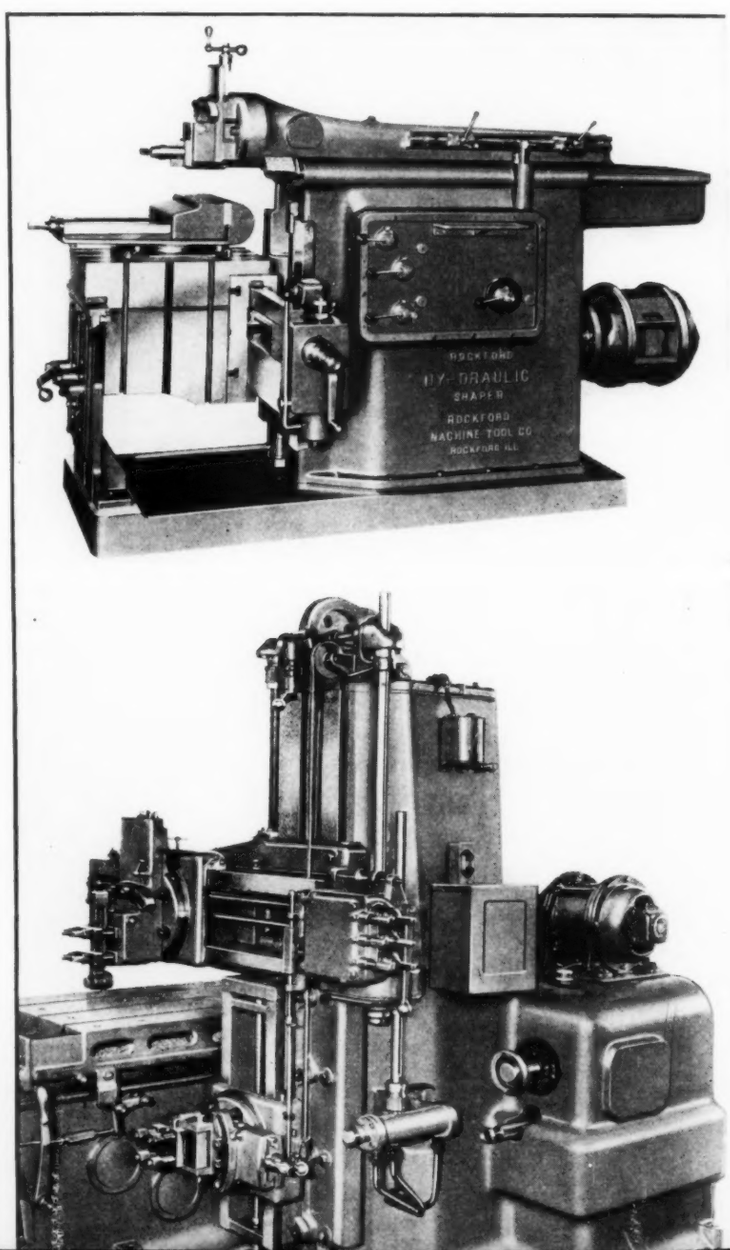
How, spurred by the introduction of tungsten carbide cutting tools, machine-tool designers turned to new materials and electrical and hydraulic devices to create machines capable of higher speed and greater production accuracy

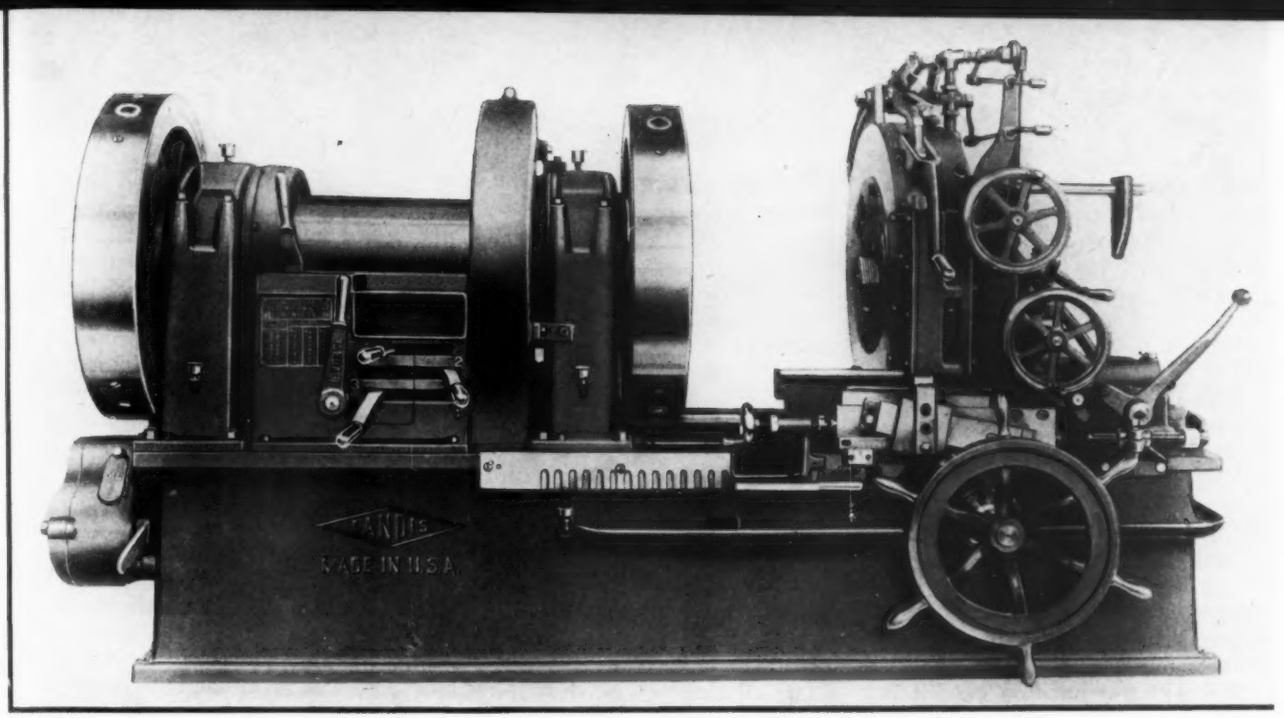
DURING the six years since the last Machine Tool Exposition, the engineering and research departments of machine tool builders were put to the task of solving many new problems. What caused these problems, the design aims that they created and the means taken to attain these aims, is best told by men of that industry.

In answer to a request of a few ideas about the new machine tools which will appear at the Cleveland Show, E. C. Bullard, vice-president and general manager of the Bullard Company states:

"In all probability the last five years have been, if not the most active, certainly among the most active years in new designing that the machine tool industry has ever known. There were probably two causes for this: first, the realization that many machine tools had lost their sales appeal and that customers were requiring tools that would produce more accurately at lessened costs; and, second, the realization that new materials and advances in the electrical arts could be used to tremendous advantage.

"With these conclusions in mind, The Bullard Company laid out an extensive program of redesign, the result of which are outstanding. The new machines, such as will be exhibited at the Machine Tool Exhibition in Cleveland, can produce at least 50 per cent more per spindle than previous machines, and in some instances considerably more. In general, the new machines are much heavier, the accuracy of the finished part is better, and they are much easier to operate. The horsepower of the driving motors has been increased from four to five times. Through the use of anti-friction bearings,





the mechanical efficiency of the mechanism has risen considerably, the significance of which is not so much the decreased power consumption, but rather that this is direct evidence of decreased wear on the mechanism with a consequent longer life and maintained accuracy.

"The attainment of the results has come from painstaking design of the various mechanisms, the proper correlation of these mechanisms, the thoughtful selection of proper materials, the use of multi-motoring and automatic operation by carefully selected electric control.

"Much time has been given to the problem of selecting material most suitable for the use to which it is to be put. Beds and housings are made from alloy cast iron having much greater strength and toughness than ordinary gray iron, but yet possessing the quality of vibration absorption, a requirement of greatest importance. Wearing surfaces such as gibs are made of a specially developed nickel iron, heat-treated after machining to give maximum wear resistance.

"Multi-motoring has resulted in fewer mechanical parts and hence the probability of decreased maintenance. The simplification thus afforded also gives greater handling ease and less lost time between cuts. Built-in or flange type motors have not been used extensively by us as it has been our experience that most of our customers prefer the standard motors which can be readily stocked and changed at almost a moment's notice in case of necessity.

"Lubrication has been studied more carefully with the result that oil filters have become standard equipment. Where flood lubrication by gravity has not been adequate, separate lines with forced lubrication have been installed. Wearing surfaces on slides are automatically lubricated. One of the safety features worked into the lubrication system is a pressure controlled switch which automatically stops the machine until obstructions in pipe lines are removed, or the lack of oil in reservoir is remedied. This feature, of course, is not entirely fool-proof, but it does remove the possibility of running a machine for hours at a time with the lubricating system not functioning.

"Along with the new mechanical features, there has been an earnest endeavor to improve the appearance of our tools. Formerly, where it was necessary to attach a mechanism, it was fastened in its bracket to the outside of machine, but in our latest designs, these mechanisms have been built in, and as smooth an appearance as possible presented. Advantage has been taken likewise of new developments in spraying lacquers, so that today the external finish of the machine is on a par with the workmanship and design of the product."

W. E. Whipp of the Monarch Machine Tool Company emphasizes the use of alloy cast iron, wear resistance materials and the application of electrical devices for automatic operation. In discussing the developments of his company, he states:

"Since 1929 there has gradually developed a far more widespread use of the new cemented carbide turning tools, which has necessitated a wider range of spindle speeds. Consequently our geared head lathes to be exhibited at the Machine Tool Show have 16 mechanical changes of spindle speeds, provide slow speeds for certain classes of work, as well as very high speeds for use with the cemented carbide turning tools.

"The use of the cemented carbide turning tools demands far greater rigidity in lathes and consequently each of our lathes is approximately 50 per cent heavier than they were built six or seven years ago. To operate successfully at these high speeds we have substituted anti-friction bearings instead of plain bearings. Whereever possible automatic force feed lubrication has been provided for sliding way surfaces, as well as automatic lubrication to the principal bearings.

"In addition to the higher duty requirements imposed on lathes through the use of cemented carbide turning tools, users of lathes are demanding greater accuracy of output with less possibility of wear. That is, machines are expected to give maximum quality and quantity production throughout their life. This has necessitated making all parts entering into the construction of a lathe of far finer materials than were even thought of six years ago.

"On Monarch lathes the lathe bed itself is a semi-steel casting containing from 60 to 65 per cent steel, 0.75 nickel, 0.35 chromium. This gives a hard, close

grained casting with a Brinell hardness of approximately 240 and a tensile strength of upwards of 50,000 lb. per sq.in. Automatic force feed lubrication is provided between the carriage and the bed way surfaces, as well as between the compound rest and carriage itself.

"We will have on exhibit at the Cleveland Show lathe beds of our standard type which will be made of semi-steel castings as indicated above, and also a lathe equipped with an all welded steel bed, the top way section being of tool steel. Another lathe bed has an inserted steel V and flat way surfaces for the carriage which are made of hardened tool steel. Also a lathe bed of our standard type, a semi-steel casting, with the way surfaces hard chromium plated, will be exhibited.

"Our idea in showing these various types of bed construction is merely to give the public the benefit of the research work we have done. We are not actually advocating any construction other than our standard.

"We will also have on exhibit two of our all electrically controlled Monarch-Keller Magna-Matic type lathes of the double carriage type. They are provided with magnet clutches for all apron and tool slide feeds, as well as a magnet main spindle drive clutch with magnetic brake. On these machines all tool slide movements, all diameters, and length of cut for each diameter, are controlled by precision limit switches operating through relays to the magnet clutches. Control buttons are so arranged that during the set-up all positioning of the carriage and tool slide is done by the inching switches. In fact the entire control to the lathe is electric, including an automatic ratchet type relay which provides any desired feeding rate for any diameter of the work piece, the different feeding rates being automatically secured as each different diameter is reached."

Speaking of radial drills, J. C. Carlton, president and general manager of the Carlton Machine Tool Company, states:

"We have forced lubrication all through our machines, making it necessary to oil only once every six months. All modern constructions are used such as hardened gears, multiple spline shafts and all safety devices, making it almost impossible for the operator to make a mistake and damage the machine. We have brought out a number of improvements over the original design such as the "electric-hydraulic column clamp" which is mounted below the motor support on the arm and thereby concealed from view and interference. We also have developed an arm-jump eliminator which is adjustable and prevents the arm from jumping or moving when the column is being locked. Similarly, our new clamp for clamping the head positively to the arm can be operated by the press of a finger.

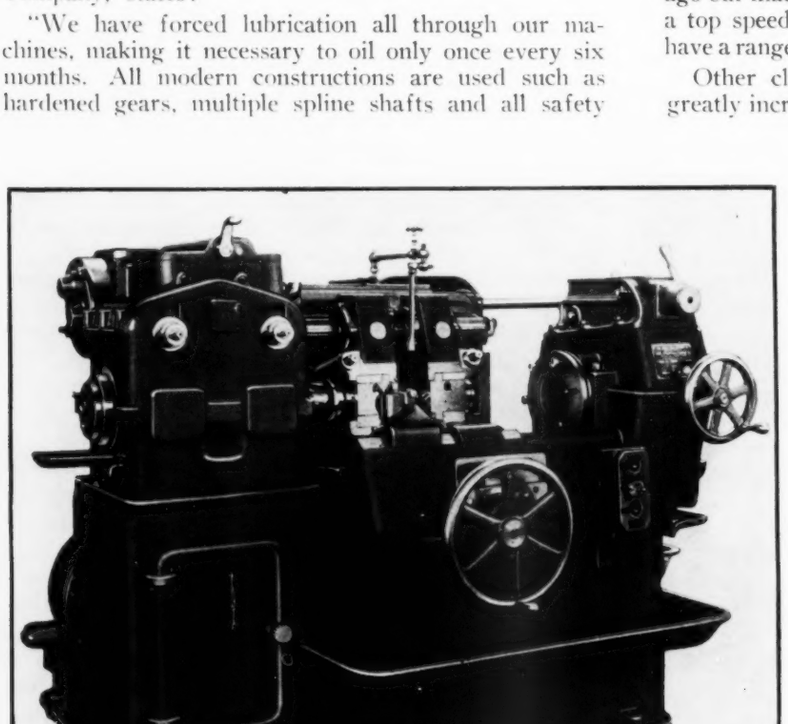
"All of the machines have pushbutton control and they are designed to have a range of speeds and feeds to do not only the heavier type boring and facing, but also to drill the smallest holes at high speeds and feeds."

Discussing milling machines, J. B. Armitage, chief engineer of Kearney & Trecker Corporation, points out the importance of a rigid design for chatter-free operation over a wide range of speeds. As the result of their researches, their new milling machines have short stiff shafts throughout the spindle drive, gear drives are specially designed for minimum backlash and revolving masses are placed as close to the spindle and revolve at as high speeds as possible.

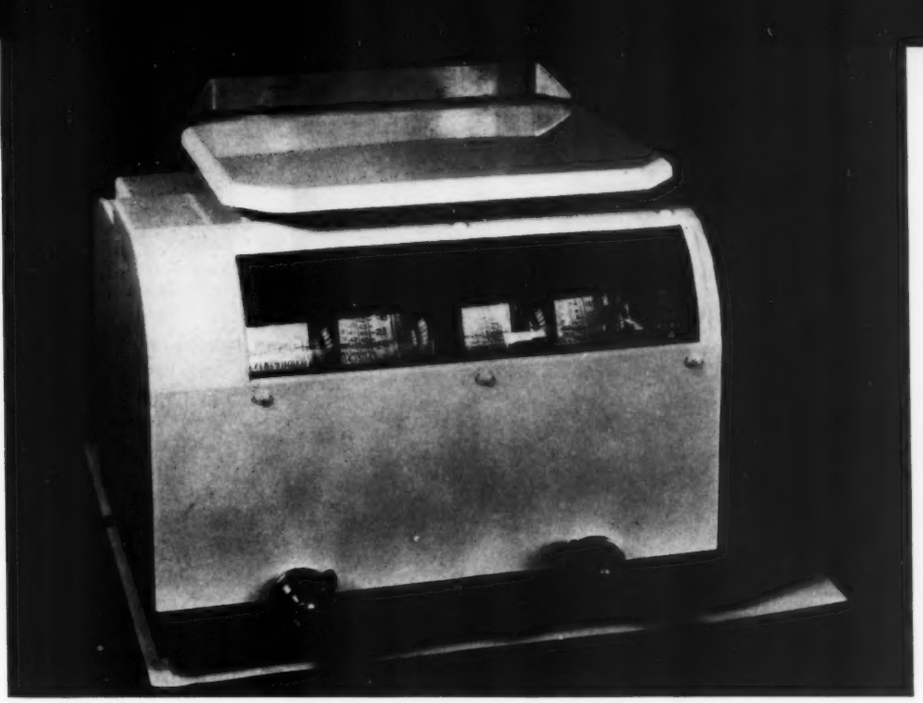
In making a comparison of the milling machines manufactured by his company ten years ago and those being offered today, Mr. Armitage points out that:

"The greatest improvement that we have made in the last 10 years in our milling machines has been the enormous increase in the chatter-free range. That is, we have extended the range of conditions under which the machine will produce satisfactory work. Ten years ago we supplied machines with feeds from $\frac{1}{2}$ in. to 16 in. per min., a range of 32 to 1. Our present machine has feeds from $\frac{1}{4}$ in. to 60 in. per min., a range of 240 to 1, and these feeds are all quite generally used, 30 in. and 40 in. per min. being very common rates of feed. Ten years ago our machines had a speed range of about 30 to 1 with a top speed of about 350 r.p.m. Today our machines have a range of 100 to 1 and 1,500 r.p.m. is the top speed."

Other changes in machine tool design include the greatly increased use of hydraulic operation, centralized controls, built-in motors and recording instruments, each of which have been the subject matter of various articles that have appeared in *Product Engineering* over the past year.



The above brief descriptions are merely indicative of the sweeping changes that have been made over the past six years in the design of all types of machine tools. In many instances they point the way to possible improvements in the design of other power-driven machinery. But of far greater importance are the new possibilities they offer to the designing engineer in the development of new products. Machining operations that were previously considered highly impractical and production economies formerly thought unattainable are now achieved by these modern machine tools. The important significance of these accomplishments to the product engineer needs no detailed explanation.



The new Toledo scale is smaller, weighs only one-third as much, and has twice as many chart graduations as the old model shown below

PRODUCT DEVELOPMENTS

Collaborative Research Behind the New Toledo Scale

● Being the result of a seven-year development program, the new Toledo Plaskon Duplex scale is more than a new type of weighing device; it is an outstanding example of collaboration. No one company alone can claim entire credit for the new design. To be sure, it is a product of the Toledo Scale Company, but the design is the result of the combined efforts of Toledo Scale designers, The Mellon Institute, Toledo Synthetic Products, Inc., General Electric Company, Aluminum Company of America, Bausch & Lomb Optical Company, and Van Doren & Rideout. Designers in all of these organizations are responsible as a group for the utility, performance and appearance of the new scale.

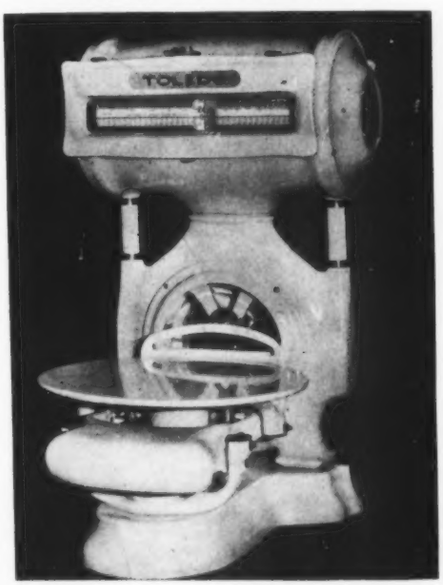
As shown in the illustrations on this page, the most obvious change apparent in the new model is one of form and appearance. Not so apparent, but of much greater significance is the reduction in weight from 165 lb. to 55½, a decrease of 70 per cent. The two factors chiefly responsible for this reduction in weight are the molded Plaskon case and extensive use of aluminum for structural parts. The molded case is the final outcome of a search for a white material that would be permanently white and entirely resistant to stain. Porcelain enamelled castings used in the former model give a finish that was entirely satisfactory, but the weight of the castings made the scale too heavy. Salesmen could not demonstrate it, merchants could not move it, counters could hardly support it.

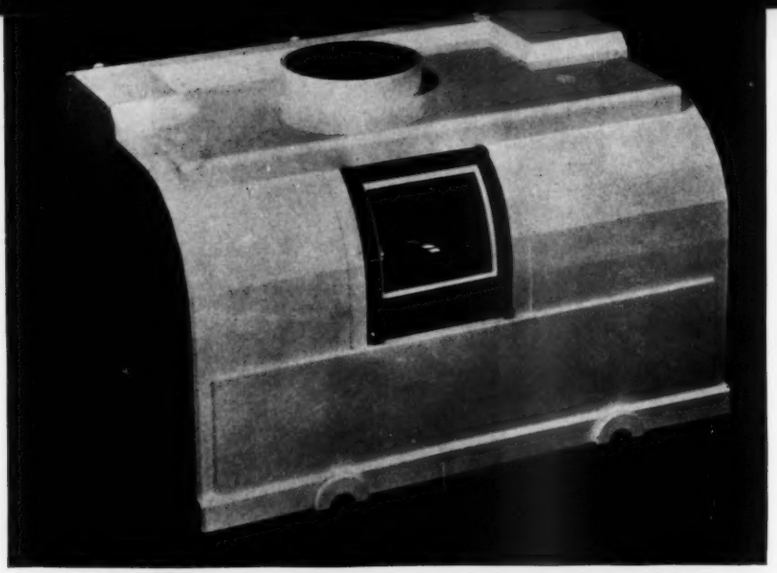
Molded plastic materials offered a solution. They required no surface preparation and no finish; they were strong, light in weight, resistant to water, and were unaffected by contact with foods and meats. But no plastic was available in a brilliant blue-white that customer preference strongly demanded.

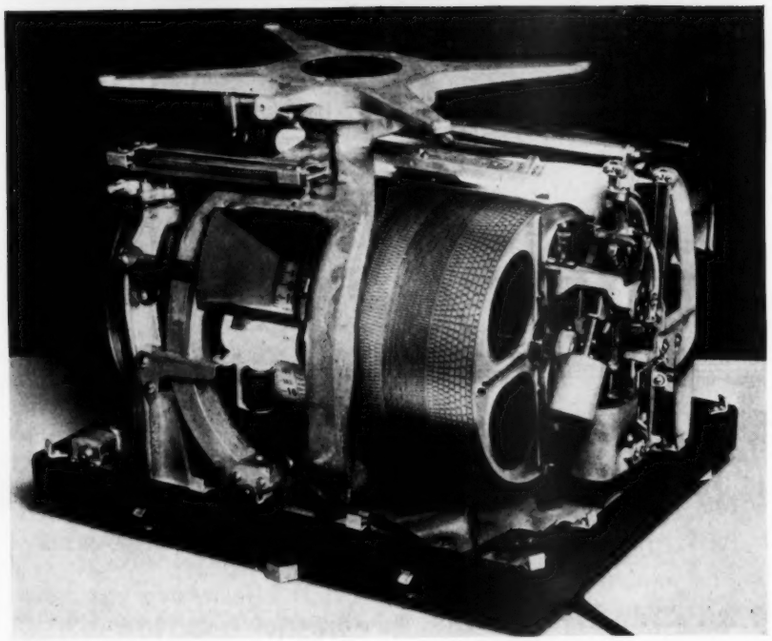
This need for a high-strength white plastic material for Toledo scales was placed before the Mellon Institute in 1928. A laboratory product that had just been developed in Europe—urea formaldehyde—appeared to be a suitable material since the natural color of the material was water white. However, tests at the Mellon Institute showed that the physical properties were much inferior to the phenol or bakelite type of plastic.

In 1929 a fellowship was established at the Mellon Institute under the direction of Dr. A. M. Howald, for the purpose of improving the physical properties of the new urea plastic. Several months of work resulted in the development of a material having low water absorption,

The porcelain enamelled cast-iron model weighed 165 lb., and required a shipping crate weighing 50 lb.







(Above) The largest plastic part yet produced—molded by General Electric out of Plaskon, a non-staining, high-strength urea plastic. (Below) Aluminum parts reduce weight and increase accuracy. Bausch & Lomb lenses magnify digits printed on the aluminum drum

good physical properties and the desired blue-white color. Tests conducted by General Electric in 1930 showed that the plastic had many other possible uses in the electrical industry in addition to its use as a housing for Toledo scales, and to carry on the development a new company was organized, Toledo Synthetic Products, Inc.

In designing the scale, the mechanism, bulky pedestal, levers, counterweight, column and the cylinders were condensed into a single rectangular prism. In styling the housing little latitude was possible in form or indentation to make the shape more varied. In its final form as developed by Van Doren & Rideout, the case was given a horizontal treatment to reduce the apparent height. As shown in the illustration, the molded case has sharp, clean cut lines and smooth plane or cylindrical surfaces, characteristic and suggestive of molded plastics.

When the final design was completed, the cover was larger than any molded plastic part previously made. There was no press large enough for the job. General Electric engineers, in collaboration with the French Oil Mill Machinery Company, designed a press 22 feet high, operated by nine hydraulic rams to mold this one-piece cover. The mold alone weighs seven tons and is the largest yet produced. Only one heat-treating furnace in the United States, that of the Lindberg Heat Treating Company, was large enough to handle the mold. Yet the molded case, the most prominent feature of the new scale, weighs only $8\frac{3}{4}$ lb. as it comes from the press.

The greatest restriction in the design of the mechanism was accuracy. Only stable parts could be used; yet the mechanism also had to contribute to a reduction in weight. Aluminum was desirable for its low weight, but aluminum castings had a tendency to age or drift. As a result of research by the Aluminum Company of America special heat-treating processes were developed for stabilizing the 14 aluminum parts of the scale. These parts weigh a total of 18 lb., 33 per cent of the total weight of the scale.

One of the lightest aluminum parts is the chart made of a thin sheet weighing 30 per cent less than the paper chart which it replaces. The decreased inertia in the aluminum chart results in faster operation. Greater accuracy in reading is obtained by placing the reference line much closer to the chart since the aluminum sheet is not subject to distortion and warping experienced with paper.

Because of limitations in length and diameter of the chart, 45,000 digits was the maximum number that could be used in former models. The new chart has 95,000 digits, the increase made possible by an optical system developed by the Bausch & Lomb Optical Company. The four lenses on the operator's side of the scale magnify the figures twice, giving two inches of readable chart surface in every inch of chart length. To eliminate distortion and color fringes, achromatic lenses made of optical glass are used. Each lens is made of two elements—one of crown glass and one of flint glass—cemented together. As can be seen in the illustration on the preceding page, these lenses give sharp definition without color fringes or distortion over a large, flat field of view.

The four lenses are carried in a frame in front of eight columns of figures. The small knob near the left of the scale places the lenses before one or the other of two sets of four columns. The reading height can be adjusted with the right-hand knob by rotating the lens frame around the reference line. Tall or

short clerks thus read the same price and the reading line is in the best range of vision for clerks with bifocal spectacles.

In addition to its greater convenience and increased utility, the redesigned scale is also easier to package than the heavy cast iron model. The old style scale had to be shipped in a strong wooden crate that weighed 55 lb., while the new scale is shipped in a fiber-board container weighing only 17 lb. This decrease in weight added to the weight saved in the scale itself results in a total reduction of nearly 150 lb. in the shipping weight of each unit.

• *Automatic Controls for Screw Machines*

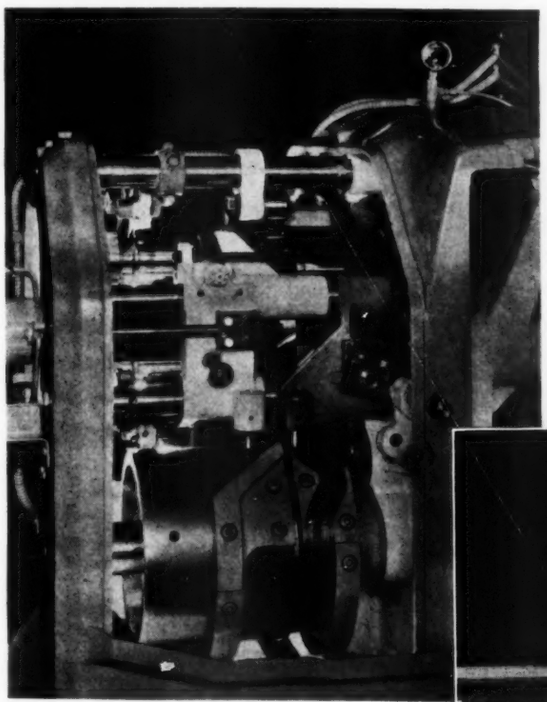
In the four and six-spindle automatic screw machines recently developed by the New Britain-Gridley Machine Company, the use of automatic control has been greatly extended. The machines cannot be operated until the lubricating system is under a predetermined pressure. Also if any of the mechanical feeds fail, automatic electric switches shut down the machine.

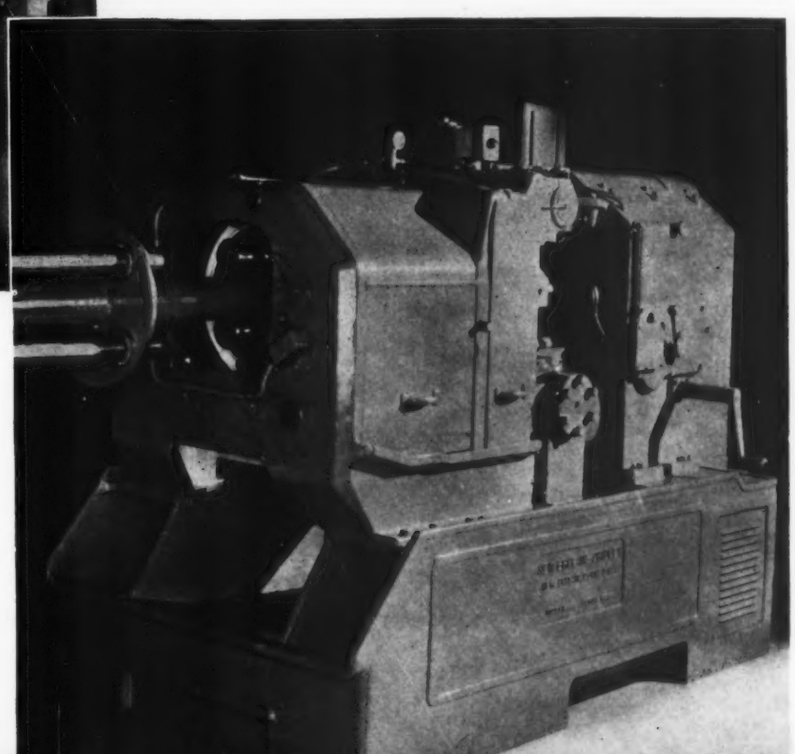
In the circulating lubricating system, an oil pressure switch closes an electrical contact at a predetermined oil pressure. In starting the machine the operator holds the starting button in, starting the oil pump motor. When the oil pressure reaches 10 lb. per sq. in., the pressure switch starts the main driving motor. A gage indicates the oil pressure at all times.

When any of the work spindles run out of stock, the feed clutch is automatically disconnected, and the machine is stopped. At the same time, the guarded red lamp mounted on top of the control box is lighted, signalling the operator that the machine requires attention. This automatic machine stop is electrically operated through a solenoid that stops the machine in a loading position with the collet open. After reloading, the operator must restart the machine.

Work rotating spindles are short in length and are mounted on oversized preloaded ball bearings to prevent radial and axial deflections under heavy tool pressures. The spindles are mounted in the spindle carrier which is geared to a Geneva indexing mechanism. Just before the spindle carrier indexes, a shoe actuated by a cam and lever lifts the carrier 0.010 in. from its bearing seat. By lifting the carrier, wear at the carrier bearing is eliminated, assuring permanent accuracy of alignment and parallelism between the work spindles and the tool slides. Friction is also reduced, permitting a faster indexing. After each indexing is completed, the spindle carrier is lowered to its bearing seat and locked by a toggle mechanism to prevent weave during the machining cycle.

Accessibility to the work, tools and mechanisms, as well as ample chip capacity is obtained by the use of a skeleton frame for the base and headstock. The side and end walls, headstock supporting surfaces and reinforcing ribs are plain and straight, with fairly small rounded radii for the corners and surface contours. To close up large openings in the skeleton frame, removable sheet metal covers are used. They slide in grooves or fit into cast recesses, giving the machine a flush and finished appearance.





Openings in the skeleton frame for both base and headstock in the New Britain-Gridley automatic screw machine are covered with conveniently removable sheet iron covers. When stocks run out or oil pressure fails, automatic controls stop the machine

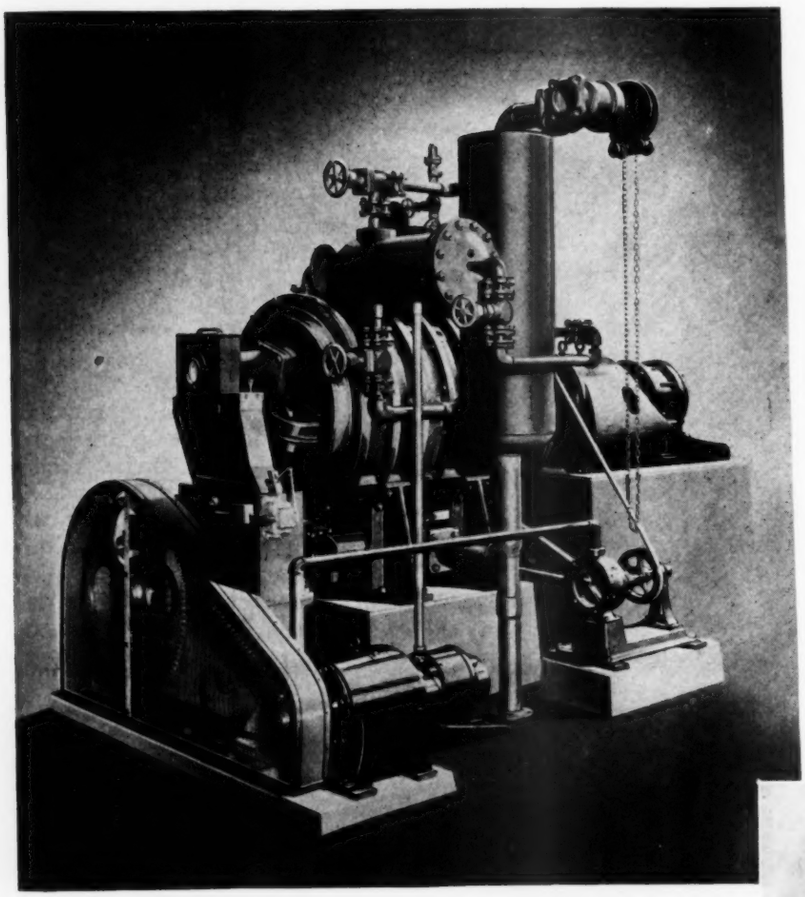
• *Continuous Ice Machine With Stellite Blades*

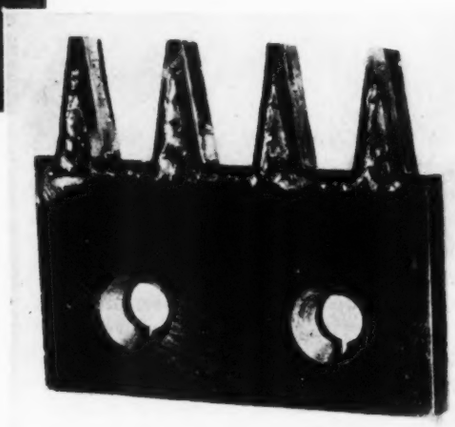
In the continuous ice machine made by the Vilter Manufacturing Company, liquid ammonia between a drum and an outer cylindrical casing causes the entire cylinder to become a direct expansion freezer. A circulating stream of water passes through the inside of the cylinder, a portion of the water freezing into a thin film of ice on the corrugated inner surface. The ice is removed by a series of revolving cutters and carried out of the drum by the circulating stream of water. Before being pumped back into the drum, the water is passed through a strainer that removes the ice flakes. Water is continuously added to the system as ice is removed.

Because of the rapid freezing action, full production rate is attained in only a few minutes, while floor space and installation costs are low compared with block ice systems.

Accurate alignment of the rotating cutter shaft in the axial direction is obtained by the use of adjustable tapered roller bearings, and the shaft is designed for stiffness with the bearings adjustable for the desired radial clearance.

Cutter blades shown in the accompanying illustration fit into the corrugations in the cylinder wall with a clearance of 0.0005 in. or less, and at times may touch the walls of the drum. To resist abrasion, these cutter blades are faced with Stellite. With cutter wear reduced and clearances controlled, a high production rate is obtained since the machine can be designed to produce thin sheets of ice that freeze rapidly.





Rotating blades remove ice as it forms inside the drum of the Vilter ice machine. To resist abrasion the blades are hard faced with Stellite

• *Random Jottings*

Standard air nozzle made of Boron carbide by the Norton Company, resists abrasion from sand or shot for sand blasting operations, giving 750 hr. or more of service before the diameter of the bore is increased 50 per cent.

All cast iron parts in the new Five-in-One tool, a home workshop machine made by the Outboard Motors Corporation, have been made of a 2 per cent nickel cast iron. This alloy was adopted because of the favorable experience with this material in the construction of outboard motors proved it to be tougher, stronger, more machinable and longer wearing than ordinary gray cast iron.

When used for pumps handling heavy fuel oil, nickel cast iron has reduced corrosion to a negligible quantity according to engineers of the Wicaco Machine Corporation. When used for such liquids as perfume, soap solutions, Citronella and cellulose acetate, the use of nickel cast iron has increased the life several times over that obtained from plain iron.

In the operation of a nest of ten 4-way valves used in a mechanical automatic control for gas manufacturing plants built by the Koppers Construction Company, leakage was greatly reduced and wear life was doubled by replacing ordinary bronze lines with centrifugally cast Ampco bronze liners reamed to a mirror finish.

By substituting monel metal for wood in the dyeing machines, the switch from one shade to another of

The "Kitchen of the Future" designed by the Briggs Manufacturing Company as part of their newly developed line of drawn-metal-porcelain enamelled plumbing fixtures. They weigh only 65 per cent as much as comparable cast-iron fixtures and are finished in color

the 300 different shades of hosiery colors can be made with minimum loss in production time, greatly increasing the production output of each machine, as experienced by one hosiery manufacturer.

Bantam roller bearings on the main rope sheaves in a new railway bridge over the Cape Cod Canal, with a lift span 544 ft. long, reduced the power required at each end of the span from 300 hp. to 150 hp. Two power plants, one at each end of the movable span, are synchronized electrically to keep the span level in all positions. The synchronized electric motors are geared direct to the main sheave, a recent development in bridge engineering.

As washers and ironers for household use are often used in humid atmospheres and frequently used and stored in damp basements, better than ordinary finishes are needed. Household equipment manufactured by Beatty Bros. are Bonderized to stabilize the paint so that it does not chip or peel off, thereby preventing rust spreading around scratches or mars.

Moving picture film, and of course the reels upon which it is wound, must be kept in humidors to maintain its pliability. In order to prevent rusting on the reels, Bell & Howell Company Bonderize the reels before spraying with aluminum paint. This combination is said to provide excellent rust resistance, and also gives reel a matte surface upon which the user can write to identify the film.

A new type of automobile being developed in England is powered by gas made from coal. The problem of carrying sufficient gas has been solved by the use of nickel-chromium-molybdenum steel cylinders, light in weight but strong enough to carry gas under 3,000 lb. per sq.in. pressure, and tough enough not to explode if damaged in accident. Two of these cylinders are slung under the chassis of the automobile. When one cylinder becomes empty, the other cylinder is connected to the engine and the empty one filled at a storage station where the gas is stored at 5,000 lb. pressure.

The Udylite plating cell uses a special, shock-resistant rubber composition for insulation. The rubber is formed, not molded, and its resistance to shocks and stresses is said to be many times greater than that of ordinary molded rubber.

In an indicating Viscosimeter built by the Sterling Engine Co., a sample of the oil passing through a power line is passed through a metering tube. The resistance to flow of the liquid through this tube, and hence its viscosity, is indicated by the static pressure as measured by a gage the dial of which is calibrated to read in Saybolt-seconds. A pressure-sensitive switch controls an electrically-operated valve that adjusts the steam supply that heats the oil to hold the viscosity constant.

Carbon steel blades in a meat chopper had to be replaced about every two weeks. The manufacturer has found that blades hard-faced with Haynes Stellite were still satisfactory after eight months in service.

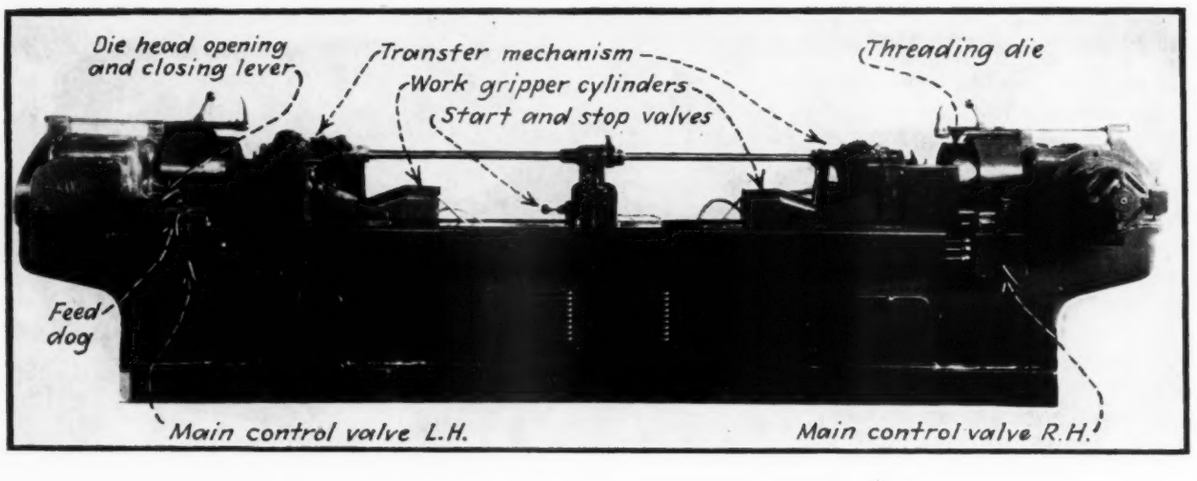
In the two-stage, air-cooled compressor built by Ingersoll-Rand Company the use of roller bearings instead of plain bearings for the crankshaft reduces the center distance between the main bearings, permitting a more compact and more rigid crankshaft. For direct-connected motor drives in the smaller sizes, the electric motor rotor is carried on the compressor crankshaft, eliminating the coupling and subbase under the motor.

In the new line of General Electric radio receivers now being prepared for fall announcement, each of the eight models incorporates the new metal tubes.

Worthington centrifugal pumps of the two-stage volute type have shafts of heat-treated stainless steel accurately ground and polished to a smooth surface. The two impellers are cast in one piece and are opposed to produce hydraulic balance. Both the impellers and the impeller guide rings are of bronze.

Modern Hydraulic Systems For Operating Machinery—II

Second of two articles illustrating hydraulic systems for operating mechanisms on pipe threading machines, motor graders, geared lathe headstocks and for automobile steering



HYDRAULIC power operates the "Lanhydro" automatic threading machine for threading, chamfering and reaming both ends of a 10-ft. length of pipe simultaneously. The work is fed down an incline to a hydraulically operated transfer mechanism that automatically places the pipe in two sets of hydraulically operated grippers, while the finished piece is being ejected. The two motor-driven headstocks carrying rotating and self-opening threading dies, approach the ends of the pipe rapidly by hydraulic feed and then slow down for the threading operation. Both movable headstocks have an individual feed control for regulating the rate of traverse speed which is coordinated with the pitch of the thread and the threading speed.

The hydraulic system as designed by the Landis Machine Company, consists of two separate but interlocked circuits. Two Vickers pumps are direct connected to a motor having shaft extensions on both ends. One pump is used for each circuit except when the work grippers are opened, one pump being used for both sets of grippers and the other for driving the work transfer mechanism. The two systems are so interlocked that the hydraulic cycle

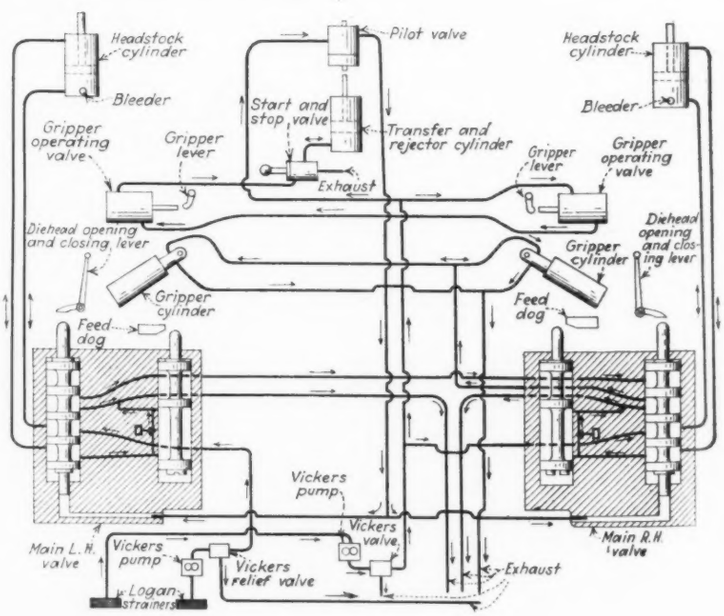


Fig. 5—Landis Machine Company's double-end automatic machine for threading, chamfering and reaming pipe 10 ft. in length. Two separate but interlocked hydraulic circuits control loading and unloading, gripper actuation and feeding and traverse movements

for both movable, die-carrying headstocks is completed simultaneously. For example, the work grippers will not open until both threading heads are in the extreme back position when the transfer mechanism starts to function. Likewise the threading heads cannot move forward until the transfer has been completed and the work grippers are closed.

These work grippers are opened hydraulically against the pressure of a heavy coil spring, so that it will not be necessary to maintain hydraulic pressure for gripping during that part of the cycle. The gripper cylinders, each containing one of the heavy grip closing springs, are the movable members, being connected to and actuating the grippers. The plungers or rams of these cylinders are pivot-mounted in the stationary carriages. Because of this movement, flexible metal hose connects the rams to the rigid piping of the system.

Because of its simplicity, ease and smoothness of operation, and fool-proof control, the Austin-Western Road Machinery Company have adapted hydraulic control to their grading machines, road rollers, motor sweepers, snow-plows and bulldozers. In Fig. 6 is shown a motor grader and a piping diagram of the hydraulic system as applied to this machine for blade, scarifier, snow plow and steering control. This double acting system is so arranged that all the pipe lines, valves, hose and cylinders are assured of being completely filled with oil at all times. The flow of oil is directed to either end of a cylinder by movement of a plug valve which opens or closes the ports as desired.

Between the tank and the pump, the latter which is of the internal gear, eccentric rotor type, the suction line is equipped with a main shut-off valve and strainer. The strainer can be removed and cleaned when the shut-off valve is closed. There are two breathers in the top side of the tank, one of which has a removable cap to allow the hydraulic oil tank to be filled. This same breather pipe has a conical screen fastened to the lower end inside the tank, to strain the oil of foreign matter. Because these machines are operated under all weather conditions the use of ice-machine or hydraulic-elevator oil is recommended for the hydraulic system. Such oil has a viscosity of Saybolt Universal, 100 sec. at 100 deg. F. and a —40 deg. F. pour point. Heavier oils cause foaming and consequent air bubbles in the line and cylinders, resulting in pulsation of the piston. When this occurs uniform grading is not possible because the blade cannot be kept in one position.

In the suction line are two pieces of rubber hose, connected with clamps to provide flexibility. To prevent the collapsing of the inner tube of the hose because of the partial vacuum in the suction line, some of the longer lengths of hose are lined on the inside with flexible metallic tubing. Between the pump and the valve there are two pieces of high pressure hose, rated to withstand 6,000 lb. per sq.in. pressure. The hose is of double duty oil resisting type and double wire braided, with the end couplings die-pressed on and cemented thereby making a leakproof joint.

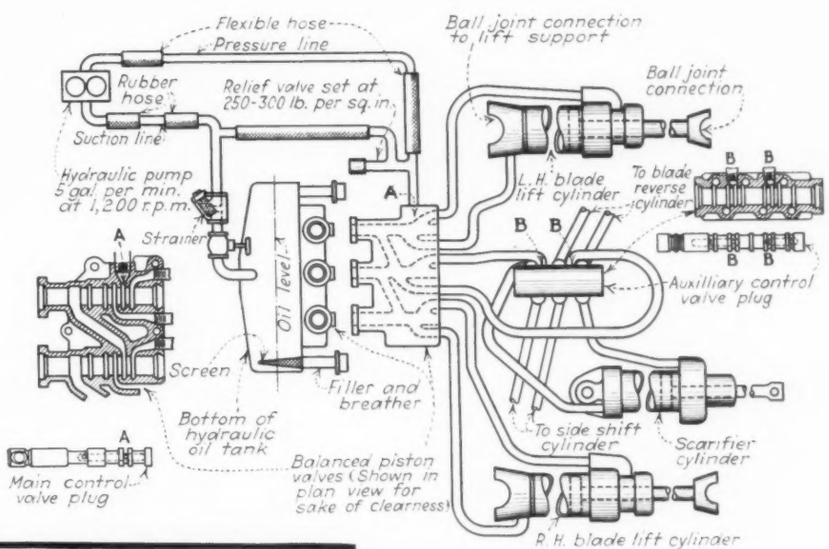
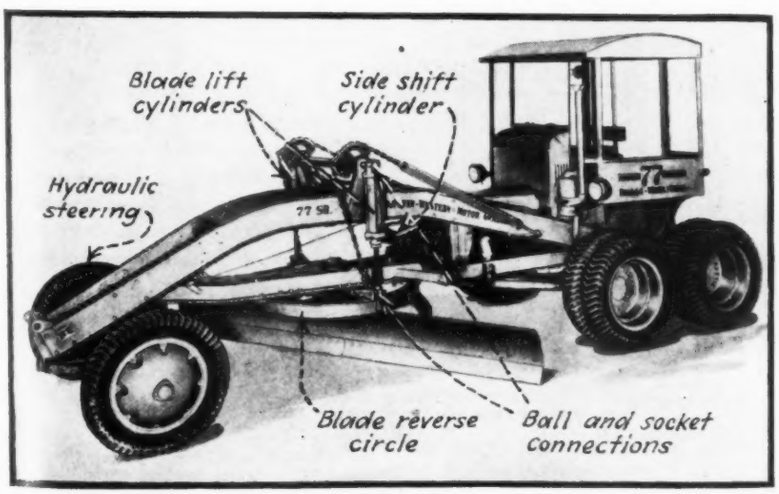


Fig. 6—The motorized grader manufactured by Austin-Western Road Machinery Company has hydraulic control for raising, lowering, side shifting and reversing the blade



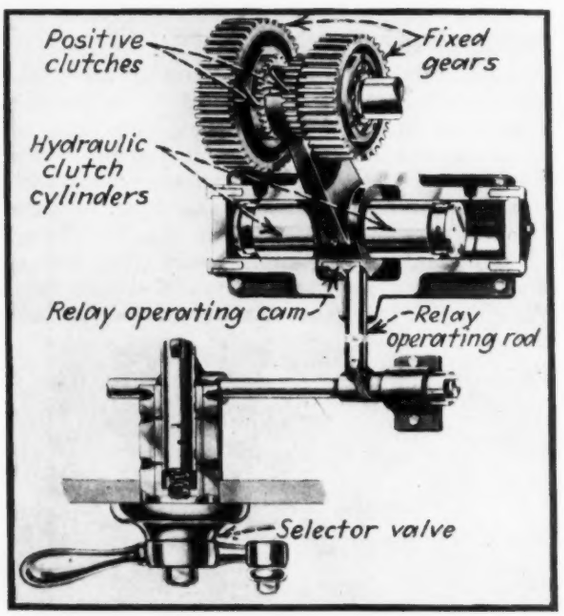
The valves which control the various cylinders are all cast in one manifold bank and located at the top of the hydraulic tank. In the diagram, side plan and cross-section views of these valves are shown for sake of clearness. The valves are so arranged that only when oil under pressure is being supplied to one side of the cylinder piston, can the oil in the opposite end of the cylinder be discharged. Thus there is at all times a solid mass of oil between each face of the piston and the control valve. This locks the piston rigidly in position when the control valve is in

neutral. The relief valve is adjusted to 250 to 300 lb. per sq.in. pressure.

The controlling of gear changes by fluid pressure is among the newest applications of hydraulic power. An example is found in the Hydratrol lathe, manufactured by the Lehmann Machine Company, shown in Fig. 7. Speed changes are made quickly without stopping the main driving pulley shafts. Selector and relay valves control, in proper sequence, the hydraulically operated disk clutches, positive gear tooth clutches and brakes. One brake is on the spindle, the other at the primary power source. The spindle brake is to prevent overrun that would occur when heavy parts revolve at high speeds, or if speeds are changed when machine is running.

These speed changes are effected by turning the speed control valve handle at the front of the headstock. The valve handle can be set to any desired speed without intermediate stop and without the necessity of manually disengaging the friction driving clutch. An automatic slide rule, built into the headstock, is coordinated with the movement of the valve handle, which is moved until the diameter of the work on the movable scale registers with the desired cutting speed on the stationary scale. The necessary gear changes are made automatically. No calculations are required on the part of the operator.

A conventional gear assembly, anti-friction bearing mounted, is driven by the three hydraulically operated clutches, two of the clutches for 16 forward speeds and one for 8 reverse speeds. They are of the double disk type and are expanded by an 80-lb. per sq.in. hydraulic pressure over a large area. The gears are engaged through three combination internal and external clutches of the positive tooth type. These positive clutches are operated by the plunger of a double acting hydraulic



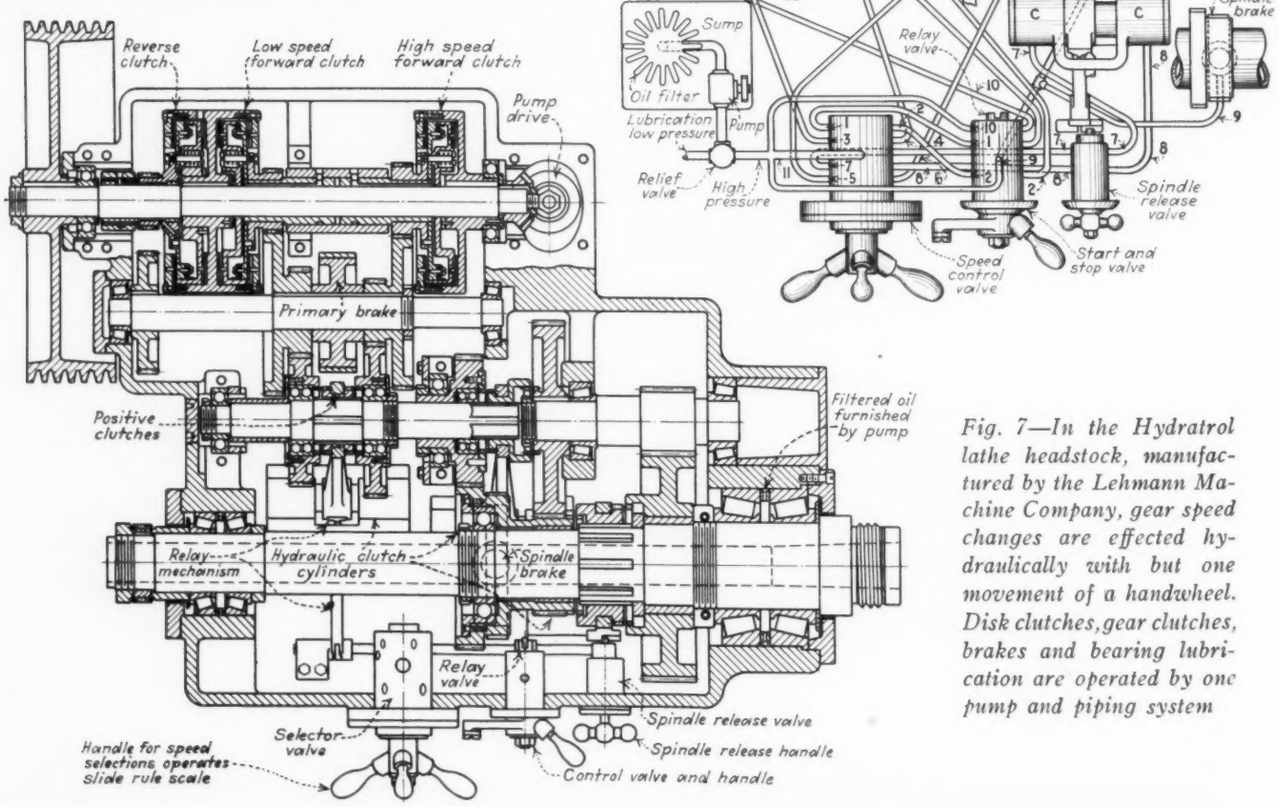


Fig. 7—In the Hydratrol lathe headstock, manufactured by the Lehmann Machine Company, gear speed changes are effected hydraulically with but one movement of a handwheel. Disk clutches, gear clutches, brakes and bearing lubrication are operated by one pump and piping system

cylinder. At the center of the plunger is fastened the shifting yoke that moves the positive clutch into the operative positions determined by the selector valves.

Oil is introduced and exhausted through annular port grooves in the cylinder. Near the ends of the plungers are annular grooves with drilled holes communicating to the cylinders. The extreme ends of the plungers are of slightly reduced diameters, which, in passing over the annular ports restrict the fluid passage and reduce the speed of the clutches through the neutral zone. The initial or disengaging movement is fast until the clutches are disengaged. When the reduced end of the piston passes over the annular port a slow movement is obtained to give time for the effective functioning of the brake while the clutches are in neutral. Just as the end of the piston clears the annular groove port, and the clutch is ready to engage, the fast movement is again effective.

Stepped cams are mounted on the periphery of the shifting yoke hubs and engage rods connected to the automatic safety relay valve. This valve makes it possible to change speed without manually disengaging the friction clutch and without clashing of the positive tooth clutches. Speeds may be changed from the highest to the lowest speed, or vice versa, or to any intermediate speed with no dwell between the changes and with but one movement of the handle.

The first step on the cam operates the relay valve during the initial fast movement. At the same time the driving friction clutch on the main shaft is disengaged, thereby eliminating its torque effect. As soon as the positive clutch is disengaged, the second step of the cam further operates the relay valve to engage the brake. The slow movement of the positive clutch during this phase gives ample time for the brakes to become effective. Before the positive clutch enters its other mating position, the brakes are released, and a slight drifting movement, originating with the friction clutches, is in effect. The accelerated movement of the positive clutch takes place immediately so that it engages easily and quickly. It is impossible to operate the lathe unless the positive clutches are fully engaged. The system has an 80-lb. per sq.in. pressure. Oil is filtered through metal filter cloth having an area of 4 sq.ft. Bearings are lubricated from the hydraulic system.

Hydraulic operation has been applied to the steering apparatus of automobiles for ease of steering while under way or for parking when the car is standing practically still. This mechanism, as shown in Fig. 8, is manufactured by the Atlas Hydraulic Steering System of North Bend, Washington. Operation is by means of a conventional steering wheel and a Viking rotary pump, the rotorshaft of which is extended and connected to the lower end of the steering post by means of a coupling. The pump is connected to a pivotal cylinder fastened to the frame, the cylinder plunger actuating the steering arm.

The steering motor or rotary pump, having a predetermined displacement per revolution, is positive in either direction of rotation and rotates only as much as the movement of the handwheel. The pump forms its own seal and lock between ports, and is provided with a compensating oil chamber which keeps the pump, cylinder and tubing full of oil at all times. The pump is connected by tube and hose to a double-acting cylinder which is pivotally mounted on the front axle or to the under side of the frame. These oil lines, $\frac{3}{8}$ in. I.D., are made of copper tubing and high pressure hose capable of withstanding 9,000 lb. per sq.in. pressure. However, tests have shown that under actual driving conditions, pressures do not exceed 50 lb. per sq.in. The oil lines are conducted through the frame by means of flange couplings. There are no control valves or springs in the hydraulic line.

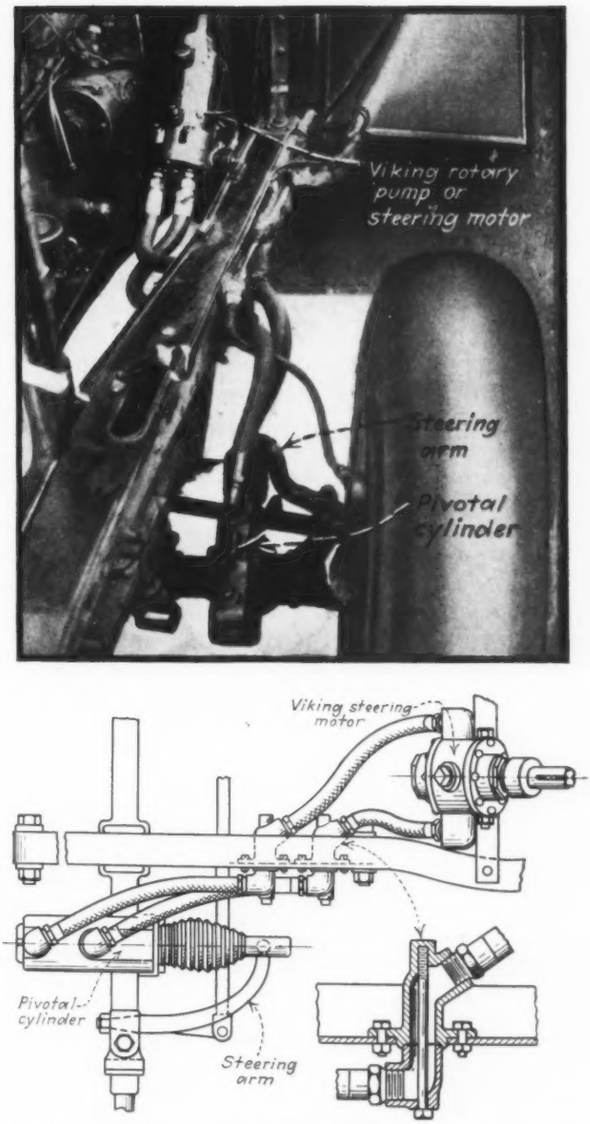


Fig. 8—Hydraulic steering as applied to automobiles and buses by Atlas Hydraulic Steering System of North Bend, Washington. A Viking rotary pump is mounted at the end of the conventional steering wheel post and operates a plunger valve connected to the steering arm

When the pivoted cylinder is mounted on the front axle, the steering arm is connected to the plunger rod by means of a ball and socket joint. In another instance this double-acting cylinder can be mounted under the frame, the piston rod being aligned with the steering drag link and connected by the ball and socket joint.

Anti-friction bearings that are special with respect to shape, dimensions or materials, and how they may be used to attain lightness, compactness, corrosion resistance, heat-resistance, or for non-magnetic applications

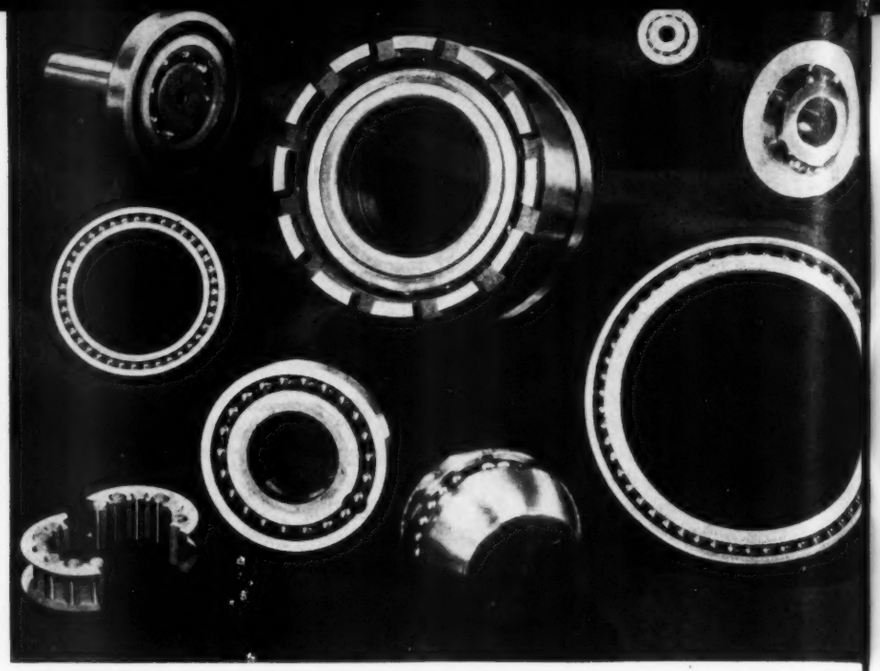


Fig. 1—Group of typical special bearings for automotive applications, outboard motors, airplane propellers, woodworking and other machinery

Bearings Designed for the

T. L. ROBINSON
Technical Vice-President
McGill Manufacturing Company

ANTI-FRICTION bearings, particularly ball bearings, have been standardized for many years as to types and sizes. This standardization has been international and a tremendous advantage to the mechanical industries in general, since it has made interchangeable bearings widely available at relatively low prices. However, there are instances where the use of special ball or roller bearings which are non-standard either as to size or design or both is highly desirable and sometimes absolutely necessary.

To the first of the classes of special bearings belong those which are non-standard only as to one or more dimensions. In the second class are included bearings that are special as to design or shape and also usually entirely special as to dimensions. The third class is made up of bearings of either of the above classes which are special as to the material from which they are manufactured. Under this last heading may be grouped stainless steel, heat-resisting, and non-magnetic bearings.

An unusual arrangement of special angular contact ball bearing—designed to carry both radial and thrust loads—is shown in Fig. 2. These bearings are used in variable pitch aircraft propellers. They retain the blades of the propeller against the centrifugal forces, which are relatively high, and at the same time they permit the blade to be rotated to change its pitch. Such bearings are used in stacks of four to six, depending on the loads involved, and must be made specially accurate in order to secure an equal stress distribution among them. Their cross-section is small as compared with any standard size, since both space and weight are at a considerable premium in aircraft design. As the rotative speed is relatively low and movement takes place only through a small angle, a ball retainer is unnecessary. Since it would reduce the number of balls in the bearing and hence reduce its load carrying capacity, the retainer is omitted. Generally speaking, for all classes of bearings the ball or roller retainer or separator serves no useful purpose at low rotative speeds. For speeds less than 500 to 1,000 r.p.m., the retainer can often be omitted and the load-carrying capacity of the bearing thereby increased.

In bearings of the second general class which are special as to form or design and also as to size, there are numerous applications which have proved not only mechanically desirable but often extremely economical as compared with standard constructions. Fig. 3 illustrates a cutter spindle driven by an integral gear and supported on two special ball bearings, the inner race of which is formed directly on the spindle. The outside diameter of these bearings is the maximum consistent with the space available in the housing and the use of a standard bearing would have reduced the spindle diameter below practical possibilities. By eliminating a separate inner raceway and grinding it integral with the pin, not only was the possible spindle size increased, but the necessity for securing the inner raceways to the shaft was eliminated.

The general scheme of making the outer raceway of

a bearing integral with a gear or cutting the inner race directly on a shaft or spindle is usually limited only by the requirement that such raceways have a suitable hardness, namely, a minimum of Rockwell C-60 and preferably C-62. In gears, this is probably best attained by case hardening, since it is usually necessary to harden the gear teeth anyhow. Shafts on which a bearing raceway is to be cut may be manufactured from a high carbon steel and through hardened, hardened locally at the region of the raceway by induction hardening, or they may be case hardened over all or only selectively at the raceway. For a through hardened shaft, a high carbon tool steel or preferably a high carbon chrome steel S.A.E. 52100, such as is usually used in the manufacture of ball bearings, may be used. When the bearing raceway must be case hardened, any case hardening gear steel would be suitable, but probably S.A.E. 4615 is preferable.

Savings in cost and weight through the use of special bearings result not only from a reduction in the size of bearings but also from smaller housings, shafts, and other allied parts. An example of this is shown in Fig. 4, which is part of the free-wheeling mechanism recently used by Plymouth and Dodge. The cam support bearing as used is superimposed on the same unit to which a standard series bearing has been applied, showing how the cumulatively increased dimensions when using standard bearings would have required a larger transmission case.

The savings thus effected were further increased by the fact that the cost of the bearing assembled on the cam was considerably less than the cost of the nearest size standard bearing. This application was also unusual in that the bearing had to carry a load of 7,000 lb. at no speed, and also had to operate at 4,800 r.p.m. under a light load. Under such service conditions the ball retainer or separator could be eliminated, since, as previously stated, the retainer function is principally for high-speed running under load. Elimination of the retainer increased the static capacity of the bearing and at the same time reduced its cost.

While great savings in cost, as illustrated, come only when large quantities are produced, cost is sometimes a secondary consideration, special shape or light weight being the primary considerations. Fig. 5 shows one of the main bearings on an internal combustion engine. The bearing is peculiar in that while it has a relatively small cross-section, it not only carries the radial crankshaft loads, but also serves to locate the crankshaft axially and at the same time takes the thrust loads which result from declutching the engine. The bolting-flange integral with the outer raceway serves to secure the bearing directly to the aluminum crankcase housing. This makes it unnecessary to bush the housing with a steel liner as is the conventional construction as the bearing is held by the bolts and hence cannot possibly wear the housing large.

The combination of a ball bearing within a ball bearing has frequently been considered for various purposes and may be particularly attractive for extremely high operating speeds. Through the differential action of such a bearing the overall speed may be divided so that the speed in either bearing is within the permissible limits of that bearing.

Operating conditions which are unusual as to temperature, atmospheric or magnetic conditions may necessitate bearings of special design and special ma-

Product

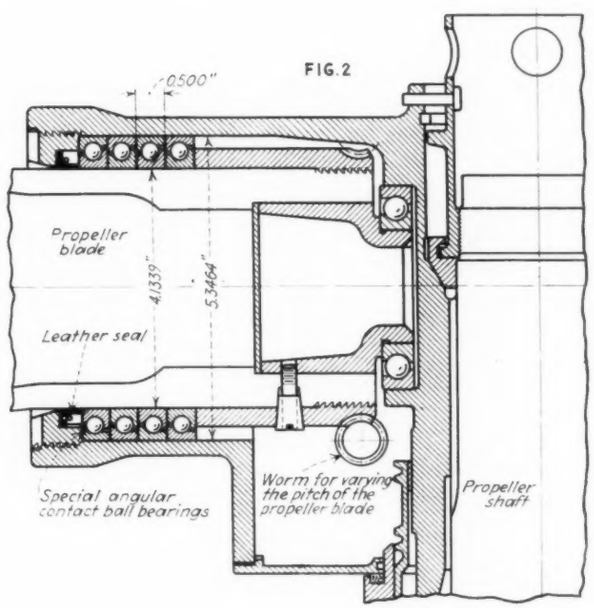


FIG. 2

Fig. 2—Special angular-contact ball bearing for radial and thrust loads used on variable-pitch airplane propellers. Fig. 3—Cutter spindle with inner race of ball bearing formed directly on the spindle, resulting in space saving and fewer parts

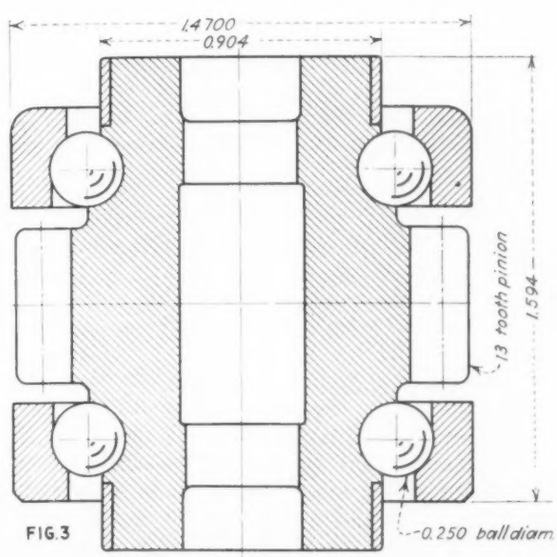


FIG. 3

terials, representing the third general class of special bearings.

Standard ball and roller bearings and needle bearings will operate satisfactorily at temperatures up to 250 deg. to 275 deg. F. if a suitable lubricant is used. For operation in the temperature range from 300 deg. to 600 deg. F. bearings with balls and raceways made from high-chromium, heat-resisting steel can be used. At temperatures above 600 deg. F. it is not generally advisable to use anti-friction bearings, but where it is unavoidable bearings can be specially manufactured from high speed steel which will not lose its hardness, and hence serviceability, below 1,000 deg. F. These bearings are also useful where they are necessarily subjected to high temperatures in assembly operations, or in the heat-treatment of adjacent parts.

Standard or special bearing designs, both ball and roller types, can be obtained with the inner and outer races and balls made of high-carbon, high-chrome stainless steel and the ball retainer and rivets of bronze or rustless iron. Generally for resisting acid, salt water or salt air corrosion a stainless steel bearing with a bronze retainer is most satisfactory. To resist alkalies, a stainless steel bearing with a rustless iron retainer gives better results. Either combination is effective against ordinary atmospheric conditions or rain water.

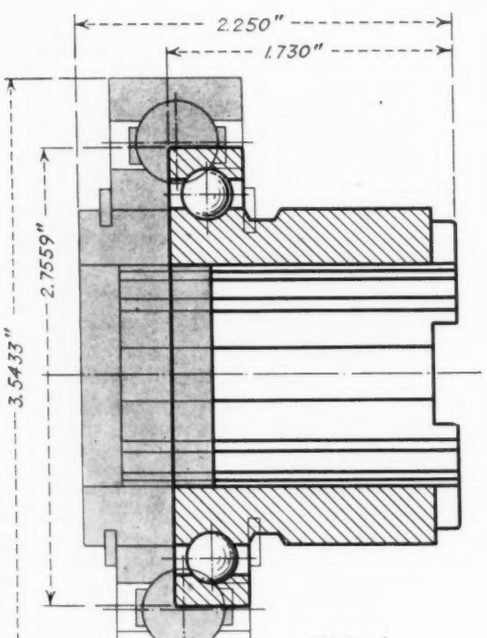


Fig. 4—Cam support bearing for a free-wheeling device. A standard ball bearing, indicated by the shaded portion, would have required a larger transmission case

Since most of the high carbon stainless steels are resistent to corrosion only when polished, all surfaces including the corners and inner lands of the outer races and corners and outer lands of the inner races must be polished. The stamping of the names, trademarks, and even size numbers on the rings is omitted, since the corrosion which takes place in the root of the letters or figures spreads to the ground surfaces.

The load capacity of the stainless bearings is 20 to 30 per cent less than that of standard bearings. This difference in capacity may be compensated for by the use of larger ball bearings, by the use of a full type ball bearing or by changing to roller type bearings.

There are many applications in the manufacture of electrical machinery and magnetic devices where a non-magnetic, anti-friction bearing is desirable. Such bearings may be obtained in ball, roller, and needle types and made from several materials to meet the service required. Bearings made of high-chromium, high-nickel steel throughout have the highest load capacity. This steel, in the fully softened condition is almost entirely austenitic in structure and represents the lowest possible magnetic permeability and can be supplied with a permeability relative to air of 1.02 (air = 1.00). Bearings of this material may have a Brinell hardness of 200 as compared with 600 for a standard ball bearing steel and the load carrying capacity would be reduced at least proportionately.

While the above-mentioned steel is practically and commercially non-magnetic, if a completely non-magnetic bearing is required it can be manufactured from aluminum bronze. Such a bearing would have approximately the same hardness, and hence load carrying capacity as the austenitic steel bearing mentioned above. It is advisable where non-magnetic bearings are required to use roller bearings rather than ball, and if possible bearings of the needle type, the greater load capacity of the roller types compensating to some extent for the lower capacity of bearings of the softer material.

Many other successful special bearing designs have been evolved to meet peculiar conditions of service or cost. While standardized sizes are always desirable, non-standard designs and materials are often necessary in engineering new and efficient machinery. And in some instances, as illustrated above, the use of special bearings may result in greater compactness with an accompanying lower cost for the completed product.

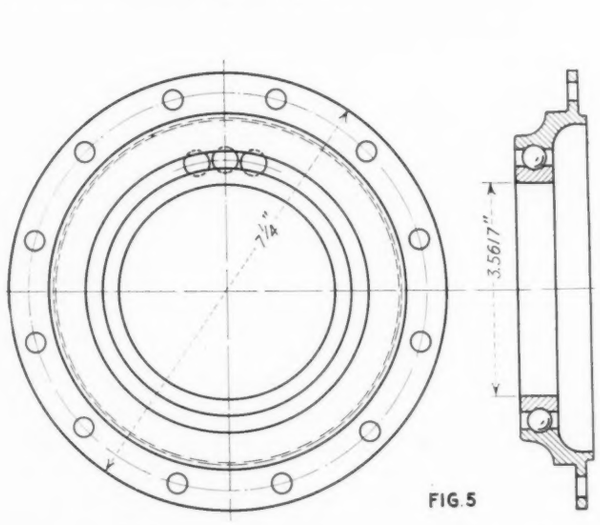


Fig. 5—Main bearing for internal combustion engine, outer raceway being provided with a bolting flange

Guide for Non-Metallic Finishes

For Central Station Equipment

Standards Division—Materials and Process Engineering Department
Westinghouse Electric & Manufacturing Company

Six groups of non-metallic finishes listed in the order of increasing durability and better appearance. In each of these groups the finish may be, in the order of durability, a lacquer type, air dried oil type, or a baked oil type finish.

Lacquer	*Oil Type Air Drying Paint*	*Oil Type Baking Finishes*
Used when fast drying is desirable on account of dusty shops or restricted floor space. In general the cost is somewhat higher and the durability lower than oil-type air dried or baked enamels. Spraying is necessary for application. Drying time 15 to 30 min. per coat. Primer 5 hr.	For general use. Special equipment not necessary for usual application, as these finishes can be applied by brushing. May be applied by spraying, dipping, or flowing where such equipment is warranted. Durability good but somewhat inferior to baked finishes. Drying time 4 to 18 hr.	Used to obtain low cost on volume production, and to obtain resistance to abrasion. Durability is good. Special spraying or dipping and baking equipment is necessary. Drying time 1 to 3 hr. per coat.

GROUP I—ONE COAT APPLICATION

Low cost—Poor durability—Medium appearance

DESCRIPTION—Used mainly for color effects and to prevent tarnishing and rusting on parts not subject to outdoor exposure. They tend to become brittle and chip off with age, especially on alloy metals such as brass and die-cast metals. Best results obtained on steel, copper, sanded Micarta and fiber.

APPLICATIONS—Baked finishes for low cost metal boxes, wood spacers, concealed parts of switches, metal frames and cabinets for indoor service, rotor castings, clamps.

GROUP II—TWO COATS, PRIMED AND FINISHED

Increased adhesion and durability. Medium grade appearance on smooth or rough surfaces

DESCRIPTION—Used to obtain adhesion on brass, and zinc, and to prevent spread of rust on steel parts subjected to moderate weather exposure. Cost is about double that of Group I finishes.

APPLICATIONS—Better grade cabinets, tanks, rotating apparatus.

GROUP III—TWO COATS OF SAME MATERIAL

Improved durability. Medium appearance on rough surfaces and good on smooth surfaces

DESCRIPTION—Two coats of the same material are used to obtain better appearance than is obtained from Groups I and II on steel, Micarta, fiber, and copper. The baked finishes are fairly resistant to outdoor exposure. Cost is about double that of Group I finishes.

APPLICATIONS—Micarta parts, switch parts, aluminum castings.

GROUP IV—THREE OR FOUR COATS

Medium grade finish on rough or smooth surfaces

DESCRIPTION—These are filled and sanded finishes to obtain a smooth finish on rough surfaces, chiefly castings. The finish is less smooth than that of Group V and is somewhat lower in cost.

APPLICATIONS—Switch gear castings, mounting plates.

GROUP V—FOUR OR FIVE COATS

High grade smooth finish, filled and sanded. Durability good

DESCRIPTION—These are smooth high quality finishes for rough surfaces. Because of more thorough filling and sanding operations these finishes are more expensive than those in other groups.

APPLICATIONS—Castings that require best appearance, brackets, metal boxes, cast brackets and bearings for machines.

GROUP VI—THREE COATS OUTDOOR FINISH

Highly durable and medium in appearance

DESCRIPTION—The inhibitive priming paint used in these finishes retards the spread of rust on sheet steel and cast iron. The cost of Group VI finishes compares with that of Group IV.

APPLICATIONS—Tanks for outdoor service, structural steel frames, housings, marine metal boxes, Micarta for outdoor service.

Storing and Preparation of Paints

Materials and Processes Engineering Department
Westinghouse Electric & Manufacturing Company

Storing Paint—Keep paint stored in a room kept at 60 deg. F. or warmer. Cold material will be high in viscosity and require too much thinner to reduce it to a working viscosity. The thinner added to cold material may cause separation of the resin and pigment.

When necessary to store in cold places, or when paint is received in cold weather, put it in a warm room a few days before using. A drum of chilled material will require several days to warm through. If necessary to use before it has reached room temperature, mix the paint thoroughly, draw off the amount needed and allow it to warm to room temperature before using.

Paints must be kept in containers as nearly full and air-tight as possible, or protected with a cover setting directly on top of the material in the can. This prevents thickening of the material caused by oxidation of the oils and evaporation of the thinner.

Amount to Order—It is false economy to order material in larger quantities than can be used in a reasonable time. Do not order in 5-gal. lots unless 5 gal. can be used within one week. Do not order in drums unless 50 gal. can be used within one month.

Stirring Paint—Thorough stirring of paint both before and after thinning is absolutely essential for good results. All pigment that has settled on the bottom of the container must be loosened up and thoroughly mixed with the remaining oil. Stir thoroughly with a paddle; tumble on a drum turning machine; stir by means of a portable mixing machine; or stir by turning the agitator attached to the drum. Turn the agitator in the drum frequently and continue stirring until the paint has a smooth even consistency. Stir frequently when standing unused, and always stir before any material is removed from the drum.

When the paint is in a smaller container, remove the head and pour off part of the top liquid to prevent splashing. Use a broad, flat, clean paddle and stir thoroughly the remaining contents until well mixed, using a rotary lifting and beating motion to lift the heavy portion off the bottom and mix it with the thinner liquid on the top. Then pour back the top liquid slowly, stirring well until the paint is thoroughly mixed to a uniform consistency. Mix thoroughly every time the paint is used.

Incomplete stirring will result in the material being thin on top and thick at the bottom of the container, the finish will be too glossy or too flat and will be off color; thick material on the bottom will produce a chalky film that is not durable and does not adhere to the surface; the thin material on the top will have poor hiding or covering power, and will contain an excess of oil and resin, which is responsible for lifting when the dried films are coated with lacquer.

(Clear varnishes and lacquers contain no pigment and need no mixing or stirring before drawing from the original container.)

Straining the Paint—Paints containing specks, dirt, and paint skins must be strained through wire screen (approximately 40 mesh) or through a double thickness of cheesecloth. It should not be necessary to strain new paint, but paint skins are formed soon after the container is opened. Paints taken from open containers should be poured through a strainer and stirred around with a brush until all the clean paint has gone through. Straining may be done either before or after thinning, but thinned paint passes through the strainer in a shorter time.

Thinning the Paint—Do not use oil for thinning paints as paints are properly made up when purchased and need paint thinner only. Paints must be thinned to a consistency suited to the method of application. Avoid overthinning. Do not use more thinner than is required to obtain a satisfactory working consistency.

Add the thinner slowly, stirring it into the paint thoroughly with a flat paddle, using a rotary lifting motion of the paddle so as to lift the heavy paint off the bottom and mix it thoroughly with the lighter material on top. When a large quantity of thinner is added at a time, it may float on top and require a much longer time to mix well than when added gradually. It also might cause a separation of the resins in the paint and produce a gritty finish. Thinned materials must be kept thoroughly stirred while in use as the pigments have a greater tendency to settle out in thinned materials.

Unless otherwise specified, the paint should be thinned until the following viscosity readings are obtained on the No. 1 Demmler viscosimeter:

Brushing....	80 sec. minimum
Spraying....	50-60 sec. (pressure tank)
	20-30 sec. (suction cup)
Flowing....	15-30 sec.
Dipping....	15-20 sec.

Maintenance of Thinned Material—Thinned material in dip and flow tanks must be stirred frequently while the tanks are in use to assure uniformity at all times. It is necessary to add thinner daily to replace that lost by evaporation. At the same time, add new material and thinner to the mixture to freshen it and to replace the material used. When not in use, keep the tanks closed with air-tight covers close to the surface of the liquid if possible.

All portable spray equipment containing pigmented materials must be equipped with power driven agitators which are permitted to operate continuously. When hand spray cans or open paint cans are used, the operators shall be instructed to stir the contents thoroughly with a flat paddle at least once an hour. Pigmented paints settle out rapidly after thinning and produce defective finishes such as chalky, non-adherent films, or gummy films which are readily attacked and lifted when lacquer is applied over them.

Variable Speed Drives in Modern Machines

New functions and improved performance that are obtainable through the use of built-in variable speed drives that give automatic control of the speed

IN MANY motor-driven machines the quality or accuracy of the work done by the machine as well as its productivity are greatly influenced by only small changes in machine speed. Change gears or variable speed motors with suitable controls can be used for many of these applications. But, more often the use of a constant speed motor and variable speed transmission is not only more convenient but also lower in cost, as exemplified in the typical drives shown here, representative of recent application of variable speed drives.

In the Hanchett grinder the speed of the rotating work table must be adjusted in accordance with the rate of feed, kind of material being ground, amount of stock removed, and the area of the ground surface. The Reeves variable speed drive permits accurate adjustment to meet each job. The Milwaukee milling machine with a built-in U. S. Varidrive gives the operator an unlimited selection of cutter speeds with a single control. In a small hammer-mill, built by the Pulverizing Machinery Company, the feed screw is driven by a separate motor through a small Link-Belt V.R.D. unit. Variations in rate of the feed give an accurate control of the particle size. Drives of the type shown in this group are compact, self-contained units readily incorporated in the design; exact speeds needed are easily selected and readily changed.

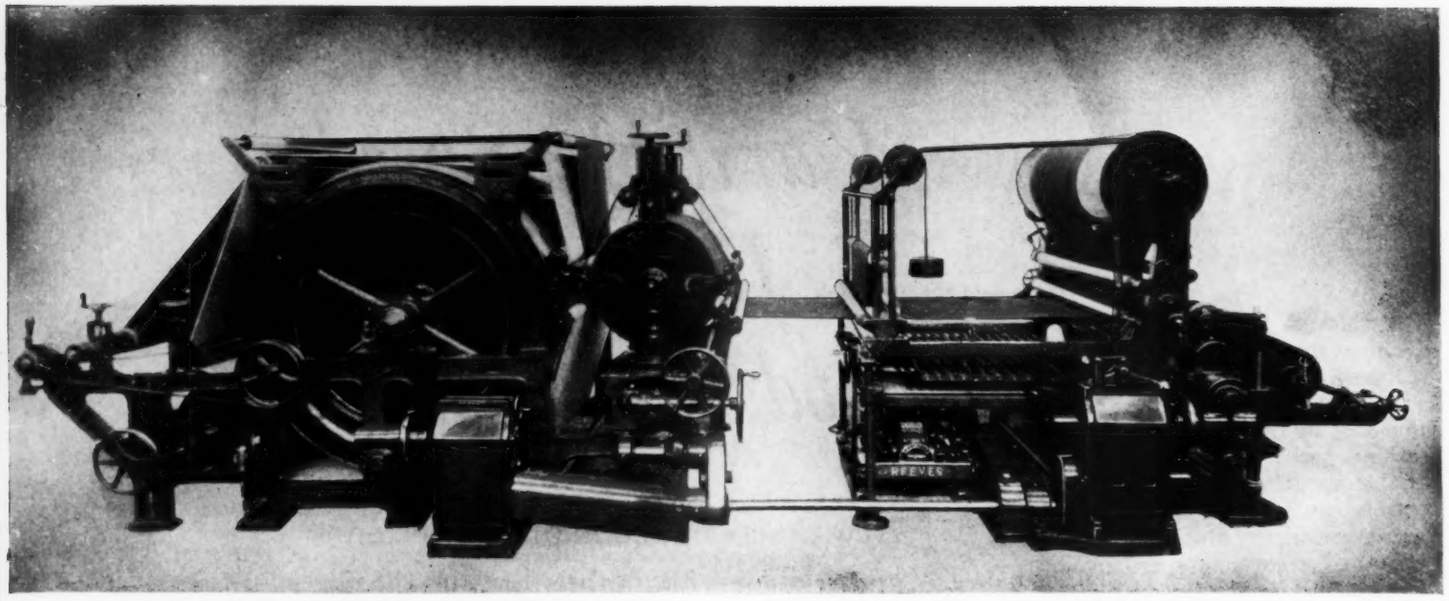
(Circle) Pulverizer equipped with a Link-Belt V.R.D. transmission

(Above) Hanchett grinder showing front view of built-in Reeves drive. (Left) Milwaukee milling machine using U. S. Varidrive for feed drive

Some machine processes not only require variable speed, but also a speed that can be accurately proportioned or adjusted in relation to some other function of the machine. In cold-roll forming machines having two or more sets of rolls, variable speed drives make it possible to advance work continuously through a series of rolls in the machine regardless of the roll diameters. Only one operator is needed, and coiling and handling between operations is eliminated.

In some variable speed drives speed ratios must be progressively increased or decreased by small amounts during an operation. In drives for spinning frames, for example, the bobbin speed must be slowly decreased as the yarn or thread is wound on in order to keep thread tension constant. This change in speed can be determined accurately for each machine and a speed changing device can be incorporated with the variable speed drive to take care of it. After the completion of one cycle of operation, the speed adjustment is manually returned to the starting ratio.

Variable speed drives used in conjunction with photoelectric devices, control the register in bag making and

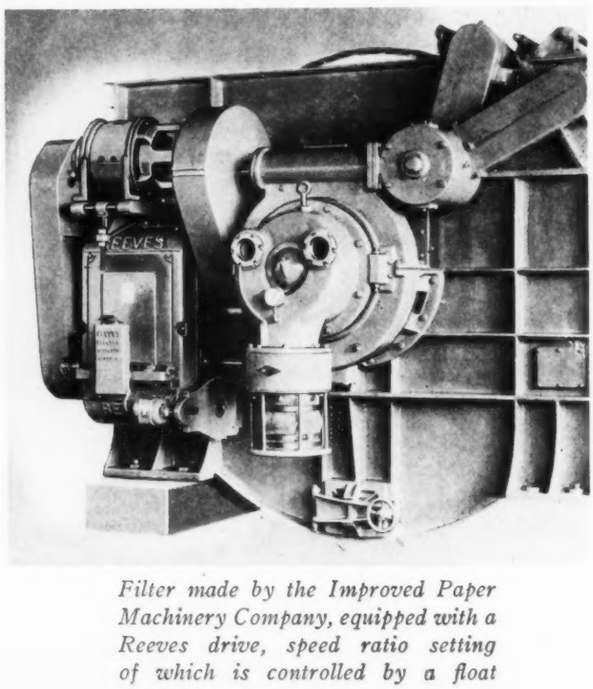


Textile finishing machine wherein rewind-roll speed is automatically adjusted by a Reeves drive to conform to the speed changes in the finishing units and to the increasing diameter of rewind roll as it fills up

wrapping machines. With manual control of register, cutter knives are driven at a constant machine speed and draw rolls are driven through a variable speed drive. Fine adjustment of the speed ratio is needed to keep the paper in register as well as to adjust for different lengths of bags. With manual control, register can be determined only after the bag is completed. Photoelectric controls for registering permit corrections to be made on each bag, greatly reducing rejects as well as allowing higher operating speeds. However, the speed ratio of the variable drive cannot be changed as rapidly as required to take full advantage of the rapid response of the photo-cell equipment. In most register controls, therefore, the variable speed drive is manually adjusted to approximately the desired ratio, and small additional corrections are made by a small motor driving through a differential. Thus, the variable speed drive permits ready adjustment of the feed to the approximate bag length, leaving only small corrections to be applied by the electronic device. In some types of photoelectric control, when persistent corrections are required in one direction on successive bags, the variable speed drive is automatically adjusted in the proper direction to bring the paper speed into closer register.

Variable speed drives with automatic control of speed ratio are also being used to synchronize two independently driven elements in a machine. For example, in the Palmer finishing machine, made by Van Vlaander Machine Company, the rewind roll speed is automatically adjusted to take care of two factors. First, as the roll winds up, the roll speed must necessarily be reduced in order to keep a constant tension on the fabric between the two separate units, the finishing drum and the rewind roll. Second, variations in speed in the first unit must be matched by the speed of the second unit. This combined synchronism is obtained by the use of a "dancer roll" unit at the point where the fabric enters the rewind unit. In the automatic control developed by Reeves, the dancer roll is free to move in a vertical direction, and is lifted by weights passing over pulleys at the top of the dancer roll frame. The height of the roll, with the fabric running over it, therefore, varies as the two machines vary in speed. Changes in height of the dancer roll, causing the chain pulley to rotate, moves a linkage terminating in a lever at the control unit mounted on top of the Reeves drive.

The speed changing shaft in the variable speed transmission is driven by a small motor, the direction of rotation being controlled by two carbon rheostats, one for each direction. Pressure on one or the other of these rheostats is exerted by a rocker the position of which is controlled by two independent levers rotating about the same axis. One lever is moved by the dancer roll linkage; the other is actuated by the speed ratio indicator. When the two levers are in line, the rocker arm exerts no pressure on either of the carbon rheostats, and no current flows to the speed changing motor. But when the dancer roll height changes, its link causes



Filter made by the Improved Paper Machinery Company, equipped with a Reeves drive, speed ratio setting of which is controlled by a float

the rocker arm to compress one of the rheostats, causing rotation of the speed changing motor until the second lever again aligns with the first lever.

With this automatic control, the speed of the rewind unit in the finishing machine is automatically changed as required to compensate for both the change in speed of the first unit and the change in diameter of the reeled material.

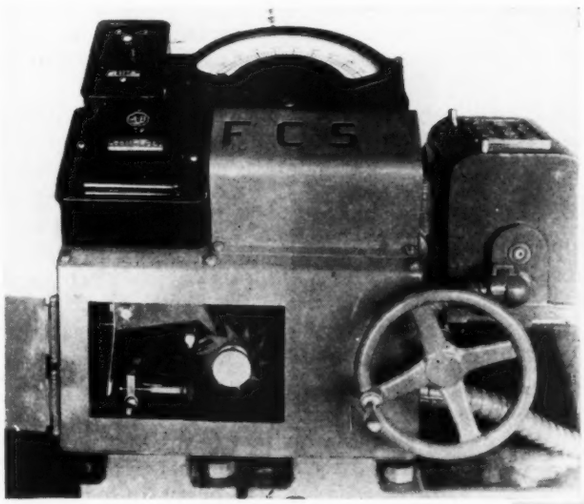
A similar type of control is used on a vacuum filter made by the Improved Paper Machinery Company, in which the speed of the motor rotating the filter drum is adjusted by a Reeves drive controlled by a float. The variable speed drive is compactly mounted in a vertical position with the driving motor supported on an adjustable motor base above the variable speed drive. The small motor that operates the speed changing shaft is mounted directly on the transmission with the chain drive inclosed by a guard. Both output and input shafts of the variable speed drive are protected by guards.

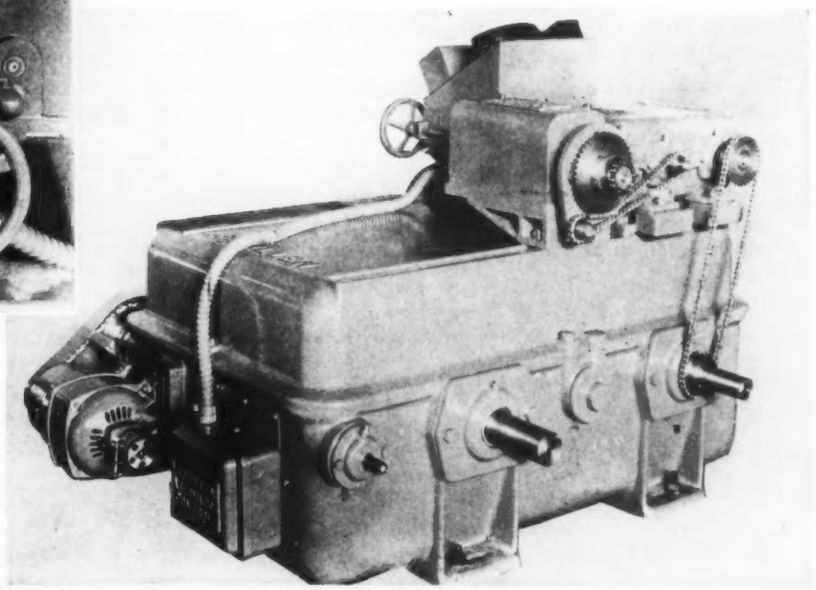
In addition to synchronizing functions, variable speed drives are also used in conjunction with automatic controls to change the speed of operation automatically according to a fixed, and often complex, schedule. For example, in a slitter and rewinder drive for light tissue or wax papers, a Lewellen automatic variable speed drive performs two functions. First, the rewinding operation is started at a slow speed when a new roll is started. After building up a small amount of wound paper, the machine operation is accelerated in a few seconds to a constant paper speed. Thereafter, the speed of the rewind roll is automatically controlled, decreasing the shaft speed as the paper builds up.

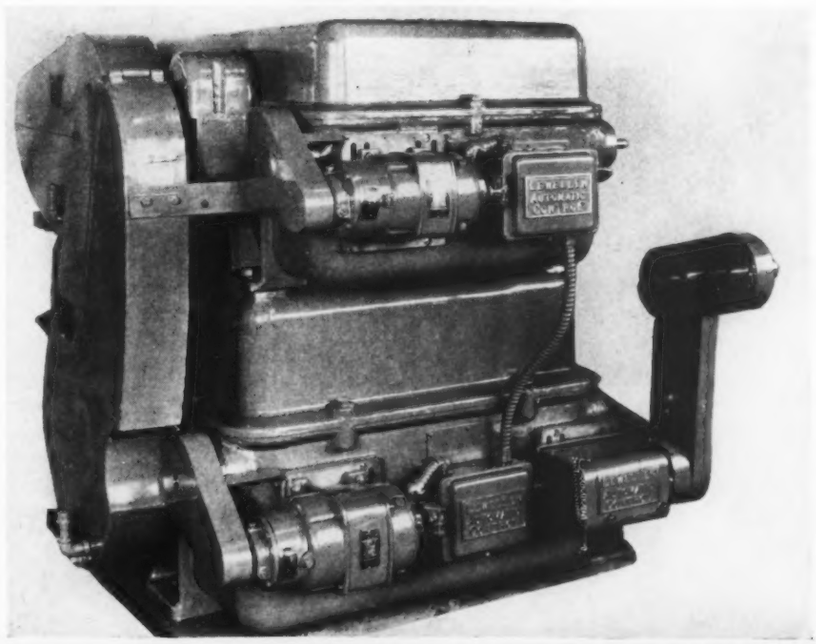
The control device for this Lewellen drive consists of a rotary contactor operated in conjunction with a smaller variable speed drive which is set by hand to the desired linear speed of the paper.

The input shaft of the small variable speed transmission is chain driven from the constant-speed shaft of the main transmission. The output or variable speed shaft of the small transmission is chain driven to a rotary contactor mounted at the end of the small transmission. This rotary contactor, in turn, controls the ratio-changing motor for the large transmission.

The rotary contactor is a comparator mechanism containing two concentric shafts, one rotated by the small hand-adjusted variable speed drive and the other chain driven from the main drive shaft of the machine. Electrical contact devices assembled to the two concentric shafts are arranged to close one or more of three







Lewellen automatic reeling drive. A rotary intermittent contactor controls the transmission ratio of the drive. Speed is indicated by the electric tachometer. (Below) Slitter-winder control with pilot motor and reduction gears for operating the speed changing mechanism, and reversing, limit and reset switches

separate circuits, depending upon the differences in speed of the two concentric shafts. From these contacts the circuit to the ratio-changing motor is completed through slip rings and stationary brushes.

Of the three circuits, the one engaged during normal running periods is adjusted with relatively close spacing. These contacts are closed by a small accumulated speed differential, and make small correction in the speed ratio. When the angular displacement becomes large, other contacts are closed, making more rapid corrections.

One complete cycle of operation for this machine includes a slow wind up of paper on the arbor until a given thickness has been wound on. At this point a roller riding on the paper just ahead of the rewind arbor closes a contact bringing the automatic control into operation. The machine speed being lower than that set on the small control transmission, the rotary contactor causes the control motor for the main transmission to increase the machine speed rapidly. As the speed reaches synchronism with the set speed, the ratio-changing motor stops.

Then as the wind-up roll increases in diameter, the rotary contactor operates the ratio-changing motor to reduce the arbor speed so as to keep the paper speed constant. To prevent hunting or over correction, the circuit to this ratio-changing motor is closed only intermittently during this stage of operation by a cam.

Synchronizing controls of this type are also used on drives in which two different machines are required to operate at a fixed relative speed.

In textile machinery the speed of any two machines working together, such as dryers, filling rolls or tenter frames, must be controlled to maintain a uniform tension and a uniform amount of slack between the machines. Floating rolls are placed between the different machines, and arranged so that the Lewellen contactor is operated by the movement of these rolls.

One of the machines in the range is driven by a Lewellen transmission on which the speed is controlled manually. This makes it possible to set the speed to suit the particular material being run and to vary the speed to meet changing conditions. All the other machines in the line are driven by a transmission the speed ratio setting of which is automatically controlled by the contactor actuated by the floating rolls.

The floating roll is carried by the cloth and moves up or down in its slot with any change in the slack. This movement operates the contactor which engages contacts in control circuits that operate the pilot motor switches. The motor operates intermittently or continuously, depending on the extent of movement of the floating roll. Thus the speed ratio is adjusted automatically.

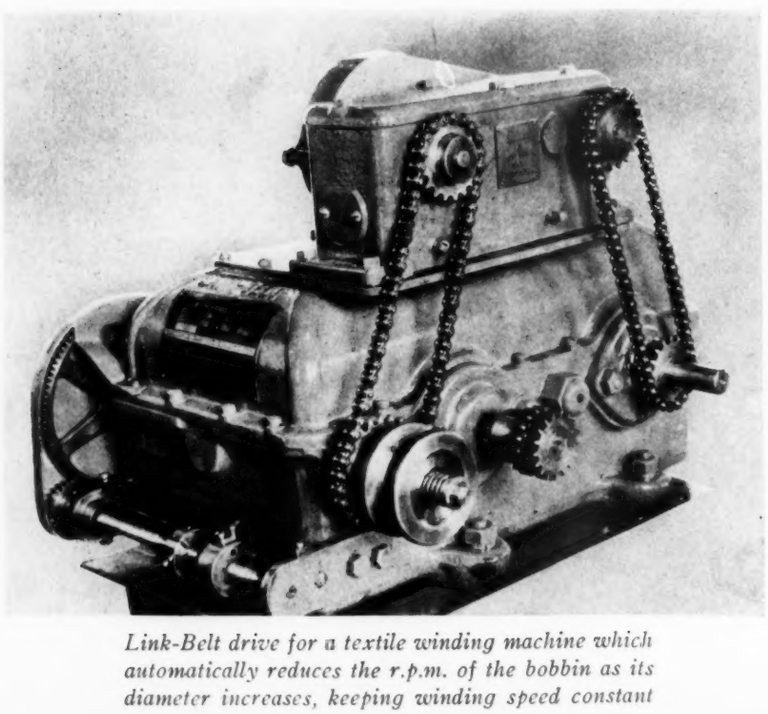
In case of cloth breakage, the roll drops to the bottom of its slot and disengages the control circuit and no further automatic control takes place until the cloth is spliced and the machines again started.

In the Autopaster, an attachment designed for Wood printing presses, a Link-Belt variable speed drive makes possible an increase of 40 per cent or more in press output without increasing press speed. This saving is obtained by changing to fresh rolls of paper without stopping or slowing down the press. The Autopaster automatically brings the fresh roll of paper up to a surface speed exactly equal to the speed of the web of paper going through the press, allowing the web to be transferred to the new roll without stopping.

This control automatically corrects for two variables, paper roll diameter and variable press speed. Both of these factors are synchronized by means of a variable speed drive. When a new roll of paper is needed, it is brought into position and paste applied. The fresh roll is then rotated by a drive combining a magnetic clutch and a variable speed reducer driven from the main press drive. The speed ratio of the drive is adjusted by means of a roller at the end of a pivoted arm which is lifted by the roll of paper as it passes. The maximum height to which this arm is lifted determines the speed setting, which is held for the remainder of the operation.

Just before the paper runs off the used roll, the web of paper is transferred to the new roll and the variable speed drive disengaged. Speed settings are so accurate that there is seldom a breakage in paper. Speeds as high as 55,000 papers per hr. are made possible by the elimination of stops for changing rolls.

Automatic speed control units are often a separate attachment. But as in the examples described here, the machine has been designed so that the transmission can be applied to the best advantage. The latest trend is a design wherein the transmission is built-in as a part of the machine.



Link-Belt drive for a textile winding machine which automatically reduces the r.p.m. of the bobbin as its diameter increases, keeping winding speed constant

COLOR Reactions on the SENSES

Color arrangement designed by the author to afford maximum visibility against both sky and earth. The underside is bright red

HOWARD KETCHAM
Color Engineer

A DIRECTOR of one of the largest transcontinental air lines recently reported a conversation with a passenger, who had become perturbed over a faint green tinge appearing on his skin. It caused the passenger to feel that he would be air-sick and soon he became so.

The official acted swiftly. "Look!" he said, taking a sheet of plain white paper from his valise, "it's on this paper, too. It's just a color reflection from something."

The "something reflected" was the play of light cast up from the yellow paint on the under-side of the plane's wings onto some color inside the cabin. Mental suggestions created by color are a powerful factor. The elimination of all unfavorable mental suggestions is only one of the reasons for making an expert study of the colors used throughout the interior decoration, furnishings and equipment of airplanes.

All color treatment should be, of course, appropriate to the functional requirements to be imposed upon the airplane. Color is ideal for imparting atmosphere in this respect. Certain hues can be used to look mellow, utilitarian, stimulating, tasteful, hospitable, masculine or pleasantly restful. This is particularly true of those planes in constant service embracing remote ports of call. The choice of colors appropriate for all seasons and climates is in such instances a necessity. Despite the actual physical apparatus provided to take care of the temperature during summer and winter, passengers are exposed to sensations of heat and cold from the surrounding atmosphere.

Colors of a certain chroma strength are essential for year-round usage in permanent equipment and interior backgrounds. Colors of rugs, upholstery, curtains, etc., chosen to emphasize warmth or coolness as desired, in accordance with the seasons, should be carefully studied and well-balanced in relation to the main background.

A general principle to remember is that colors are said to be "warm" when red or yellow is added to the basic ingredient, and "cool" when blue is added. In order to arrive at a satisfactory appearance of balance, colors should be graded in sequence, the lightest color at the top and the darkest at the bottom.

A minute but pleasing note in avoiding monotony is contributed by light-reflecting colors used on window releases, sills and hardware in general, curtain rods, ventilator and light outlets. These are made in aluminum colored by the Alumilite process to combine with the ensemble details required for the interior, such as curtains. Proper planning can supply an orchestration of related colors which add much to the good looks of aircraft interiors.

With the correct choice of color it is easily possible to secure an appearance of the greatest possible spaciousness. This is of vast importance in overcom-

Illustrating color combinations for various degrees of legibility, as set forth in the accompanying table

ing, as much as possible, the aspect of space limitations imposed by the relatively small interior areas of certain designs of planes.

Color is important as a glare neutralizing agent. Unless this feature is properly provided for, a color scheme may contribute unnecessarily to the eye strain imposed by sunlight reflected from wing surfaces. This is a problem for special consideration in all instances where the underside of a plane's wing serves to trap intense light and direct it into the plane.

Color treatment of the pilot's cabin is governed entirely by necessity. Glare is a hazard at all times, particularly in night flying. No color that gives surface reflection can be permitted. Dark gray or black keep illumination down to the essential minimum—thus we find black instruments with radium dials. It is possible to tie the appearance of the pilot's compartment in with the balance of the interior color treatment by repeating a subdued value of the principal upholstery color used in the seat coverings. Thus a rich maroon can add a touch of completeness to the appearance of the entire ensemble. This note is of special practical interest for decorative treatment to be applied to private air yachts.

The effectiveness of decorative color features for plane interiors can be largely nullified by faulty lighting. Improperly balanced lighting equipment can change the hue of wall colors disastrously. Unless light is corrected for color, greens, browns and maroons that appear to be of full hue strength under ideal daylight conditions acquire a marked yellowish hue characteristic. Blue when insufficiently iluminated assumes the appearance of gray although this hue holds its identity in the failing light of evening longer than any other hue.

In this connection, it is of practical interest to observe the reflection factor for light from Mazda lamps, as reported by the lighting research laboratory of the General Electric Company at Nela Park. The measurements are of special merit, having come from a laboratory which has no interest in selling a particular brand of paint.

Color of Paint	Reflection	Color of Paint	Reflection
White (gloss)	84%	Light gray	59%
White (flat)	82	Buff	55
White (eggshell)	81	Light blue	52
Ivory white	79	Medium green	49
Cream	74	Tan	48
Aluminum	73	Medium blue	43
Ivory tan	67	French gray	32

Our visual sense is a most deceiving faculty. We can be entirely misled as to the exact size, weight and proportions of an object. Density and weight are stressed beyond their actuality if the object is colored black, red, or orange in comparison with objects colored yellow, blue or green. Color also controls the appearance of size. An automobile finished in black has a heavier, more substantial appearance than one finished in a light color. Furthermore, color harmony and appropriateness foster a sense of quietude and stability; spaciousness is induced by the use of lighter colors.

Yellow is a color to be used, if at all, with the utmost discretion in the interior of a plane. This hue is known to contribute to any predisposition to air sickness.

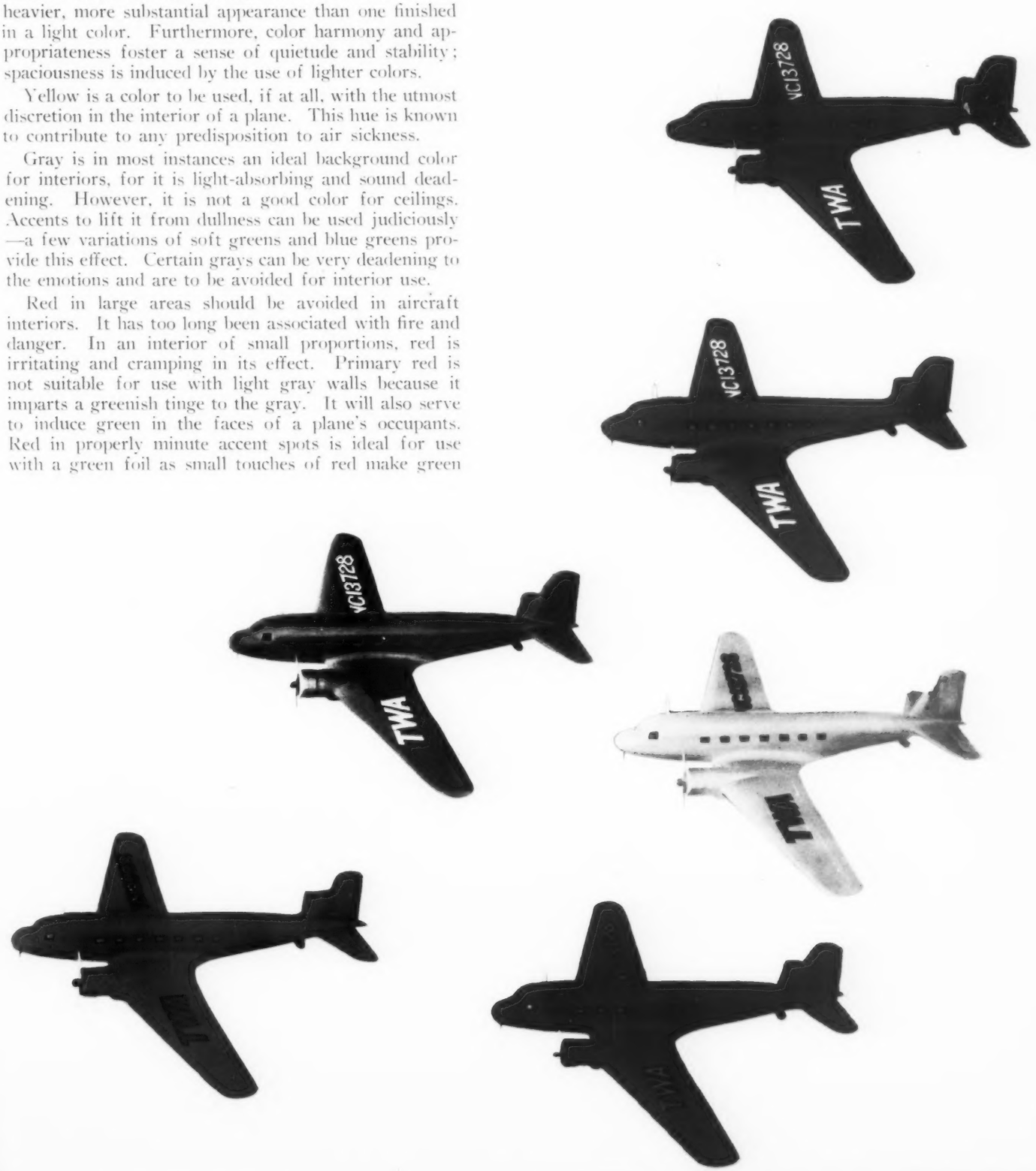
Gray is in most instances an ideal background color for interiors, for it is light-absorbing and sound deadening. However, it is not a good color for ceilings. Accents to lift it from dullness can be used judiciously —a few variations of soft greens and blue greens provide this effect. Certain grays can be very deadening to the emotions and are to be avoided for interior use.

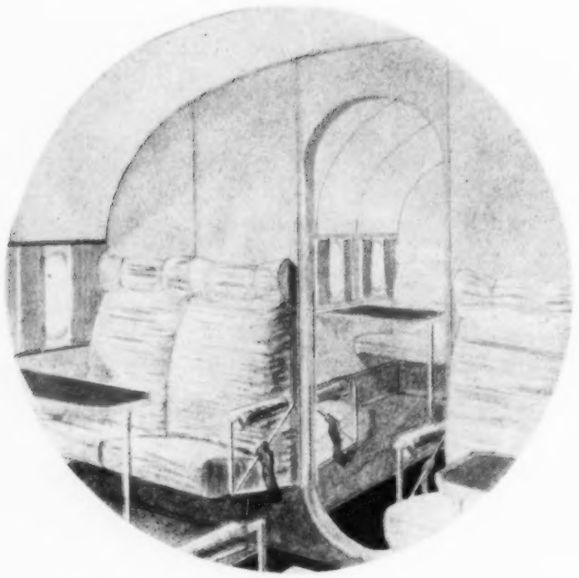
Red in large areas should be avoided in aircraft interiors. It has too long been associated with fire and danger. In an interior of small proportions, red is irritating and cramping in its effect. Primary red is not suitable for use with light gray walls because it imparts a greenish tinge to the gray. It will also serve to induce green in the faces of a plane's occupants. Red in properly minute accent spots is ideal for use with a green foil as small touches of red make green look greener. Green is the most soothing of all hues.

Blue is excellent, because it is a receding color that contributes an aspect of added space; it is also restful and agreeable to live with.

Certain shades of green, wisely placed, can be used most advantageously. Its chief recommendation is that it is the medium between "cool" and "warm" colors.

Because the colors of earth and sea are dark the upper exterior portions of planes should be in light bright colors so as to be readily recognized in the event of a forced landing. The reverse is true of the under portion. The sky is itself the light, bright area. The





Sedate aristocratic blue with contrast shades of orange, for the interior of luxurious Pan American Airliners. Colors by Ketcham

under side of a plane should therefore be treated in dark colors.

From the standpoint of visibility, aluminum is the best color for the upper exterior portion of land planes. International orange, which is the complement of sea blue, is effective on seaplanes. Three hues which contrast most visibly with both sky and sea are red, orange and yellow. A smart color for the exterior of a private plane is a certain vermillion because of its maximum visibility when seen against blue or gray of the sky area.

Distance legibility is the main factor in the choice of color for such items as ownership designation, insignia, or lettering. The following table of color combinations ranks them in order of visibility:

Legibility	Decoration	Background	Legibility	Decoration	Background
1	Black	Yellow	8	White	Red
2	Green	White	9	White	Green
3	Red	White	10	White	Black
4	Blue	White	11	Red	Yellow
5	White	Blue	12	Green	Red
6	Black	White	13	Red	Green
7	Yellow	Black	14	Blue	Red

In the instance of license numbers and ownership insignia, it is not at all necessary to be restricted to the use of black and white. A range of color combinations could be developed to distinguish ownership designation, just as the colored bands around the smokestacks of ships denote the fleet to which each belongs.

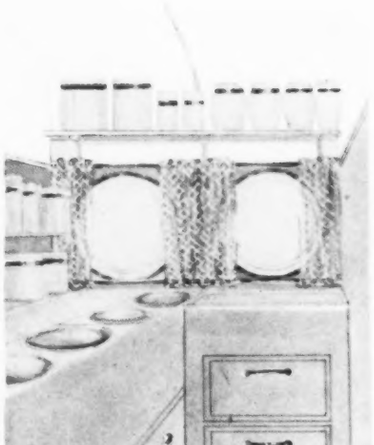
A one-third area of any color can be made to stand out noticeably against two other colors occupying twice as much area. This is because our adaptive visual senses have become accustomed to overlook actual differences. Our intellects are influenced by illusions.

A medium, such as aluminum paint for instance, furnishes an excellent aircraft finish because of its intrinsic beauty and light weight. It covers more advantageously than other paints because of the opaque character of the fine flakes of aluminum. Add to this main color an accent of scarlet, and an unusual exterior color combination is assured because of the extreme contrast of the cold aluminum color with the warm scarlet.

Today aviation companies have an unexcelled and unlimited opportunity to attract a volume of business through new, smart and attractively color decorations, for both interiors and exteriors. Proper color choice is by far the most desirable single factor in appearance appeal. It affords a practical, easy and low cost escape from standardization.

Before airplane travel reaches the competitive stage with other modes of travel, aircraft operators will have fully capitalized upon appearance appeal. Only then can they become identified as the acme of perfection in modern transportation.

Functional validity, appropriately enhanced through significant color treatment is a factor of leadership that will enable certain transport operating companies to outstrip their less colorful rivals.



Red Alumilite used as an accent color on the hardware gives the neutral green, on the walls and equipment a clear and restful appearance

Samples of Alumilite colors

QUESTION AND COMMENT

Small Diameter Motor for Stone Cutting

R. H. DAVIS
Chief Engineer
Lincoln Iron Works

● In the stone cutting industry it is necessary to use machine tools as in metal working, but the conditions which must be met in such work are quite different. For example the stone planer shown in Fig. 1 has the coping or molding wheel mounted directly on the shaft of a special, small diameter motor. The motor is tilted with the cutting wheel for making bevels at various angles, or it may be turned so as to cut across the table. The head is arranged to swivel so that the arbor can be used in any position between horizontal and vertical.

Before the development of this special small diameter motor the grinding wheel arbors had been driven by belts, silent chains, bevel gears or spiral gears. Because of the high arbor speed all of these types of drives had a short life. Therefore, it was desirable to have the wheel directly on the shaft of the motor. Because of the limit imposed on the diameter of the grinding wheels by safe peripheral speed, and the fact that the motor must pass over and clear the stone being worked on, a small diameter motor was necessary.

To meet these conditions a double-rotor construction was used to keep the diameter small. As shown in Fig. 2, the motor has one side flattened to $5\frac{5}{8}$ in. from the center line. The shaft is $2\frac{7}{8}$ in. in diameter and is threaded and provided with collars to take abrasive wheels up to 10 in. wide. Double-row ball bearings of excess capacity are used for the arbor to take both the radial load and the thrust imposed by a formed grinding wheel or the thrust from the weight of the rotor when the motor is used in a vertical or inclined position. Labyrinth seals as well as packing rings are used to retain the lubricant and exclude dirt, abrasive and water.

This motor is air cooled and self-contained, requiring no external motor-driven blower. To protect it from the abrasive and water thrown off from the grinding wheel, the cooling air is drawn in from the end opposite the grinding wheel, and is expelled at the wheel end.

The motor is a squirrel-cage type rated at 30 hp. at 1,800 r.p.m. As shown in Fig. 1, the motor is used with the feet up and the flattened side down.

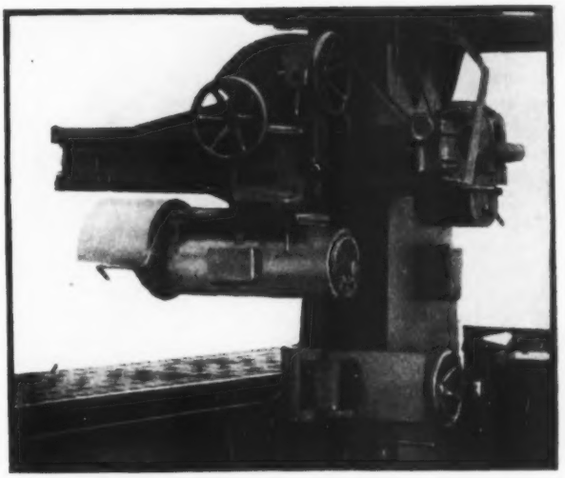


Fig. 1—In stone cutting planers made by the Lincoln Iron Works, the grinding wheel is mounted on the spindle of a small diameter motor

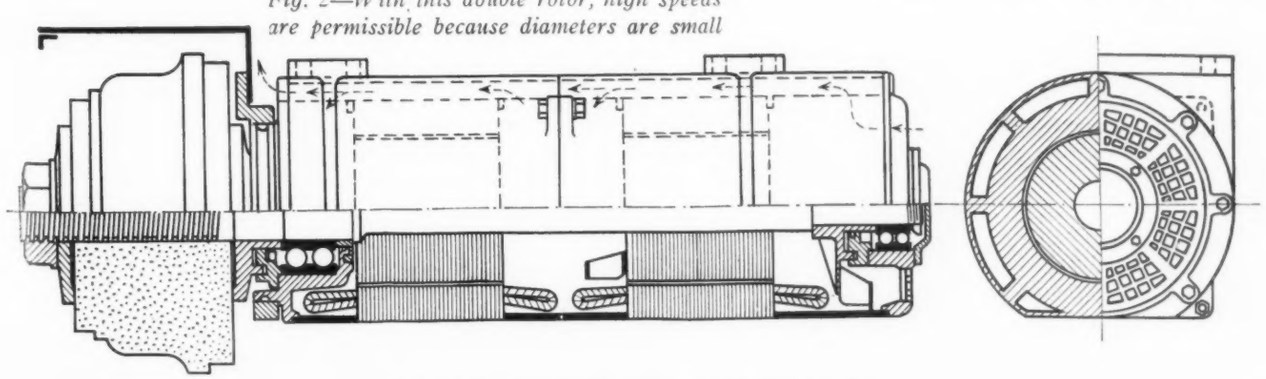


Fig. 2—With this double rotor, high speeds are permissible because diameters are small

Effect of Specimen Length on Test Data

VICTOR TATARINOFF
Pilsen, Czechoslovakia

● Methods of determining the ultimate strength of materials in tension give data for the designer's use, but tests relating to shear or torsion should be utilized with a certain caution when test specimens do not correspond with actual designs. Length, cross section, and proportions may cause large deviations in measured strength as shown by the data in Table I for silico-manganese steel of a composition similar to SAE 9260. Values for the ultimate strength were calculated from the common torsional stress formula on basis of twisting moments resulting in the rupture of specimens. For a rectangular section the twisting moment M in lb.-in. is expressed as follows in terms of the width b, thick-

ness d, the ultimate strength S and a constant k depending on the ratio of width to thickness.

$$M = k\,b\,t^2\,S \qquad (1)$$

For flat material $\frac{3}{16}$x1$\frac{3}{4}$ in., quenched, the failure occurred at a value of 10,900 lb.-in. for M as determined from this relation using a value of 0.315 for k. The corresponding value for S is 565,000 lb. per sq.in. This value is much higher than the tensile strength of the material, which is 242,000 lb. per sq.in. The material before quenching had a tensile strength of 156,000 lb. per sq.in. but the calculated torsional stress is 444,000 lb. per sq.in. Since the torsional strength is, as a rule, lower than the tensile strength by about 10 to 25 per cent, the large differences shown in Table I must be attributed to the effect of specimen length.

The character of fracture in these torsional tests differed greatly with the ratio of length to width. The quenched specimen made of flat steel $\frac{3}{16}$x1$\frac{3}{4}$ in., broke diagonally, while the quenched specimen made of $\frac{5}{8}$ in. square steel cracked transversely. The square specimen with the relatively high ratio of length to width had a low strength factor. This difference in character of fracture is caused by reaction forces arising at the end fixtures.

It is evident that Equation (1) will require corrections on the basis of the ratio of length to width. From the data given in Table I the correction factors for the ultimate strength in torsion are shown in Fig. 1, with correction factors plotted logarithmically.

As an example of the use of these curves, a quenched specimen 5 in. in length, made of $\frac{1}{4}$x1 in. flat steel, shows an ultimate strength in torsion of 350,000 lb. per sq.in. This value is corrected by dividing by 1.87, the factor corresponding to the value of 5 for the ratio of length to the width. Thus a stress of 350,000/1.87 or 187,000 lb. per sq.in. is obtained from which the allowable fiber stress can be then established by dividing by the factor of safety.

Table I

Test Specimen				Calculated Torsional Strength in lb. per sq.in.		Ratio of Test Strength to Minimum Value	
Shape	Cross Section In.	Length In.	Ratio, Length to Width	As received	Quenched	As received	Quenched
Round	$\frac{3}{8}$	6	16	125,000	220,000	1	1
Square	$\frac{5}{8}$x$\frac{5}{8}$	6	9.6	124,000	258,000	1.072	1.17
Rectangular	$\frac{5}{16}$x$\frac{1}{2}$	5	10	198,000	278,000	1.58	1.26
Flat	$\frac{3}{16}$x1$\frac{3}{4}$	4$\frac{3}{4}$	2.72	444,000	565,000	3.55	2.55
Flat	$\frac{5}{64}$x1$\frac{3}{16}$	4$\frac{3}{4}$	4	.....	526,000	.....	2.39

Procedure in Product Development

● "How can our product be improved?" Alert designers never admit that question as finally answered, but an approach to a solution can be made by setting down definite objectives in a logical order, breaking down the problem into a step-by-step solution. The following are the five component parts of the general question of product improvement:

1. Basic Processes — New methods made possible by modern developments in such processes as electric welding, extruding, electric heat and heat-treating, die-casting, plastic molding.

2. Materials and Design—New designs and colors possible with modern light alloys, molded plastics.

3. Testing — Comparison of factory tests with most severe service conditions.

4. Packaging—Modern package designs, and the possible use of a permanent package.

5. Customer Wants—Prompt handling of customer complaints. Periodic analyses of complaints for possible design or service improvements.

Field studies for close check on changing customer habits and requirements.

Product improvements obtained from this analysis not only bring a better article, but may also result in substantial reductions in cost. An outstanding example is the application of electric arc welding to the assembly of wire shelves for electric refrigerators. Not only was the arc-welded shelf much stronger, but the welding process was ten times as fast as the soldering process formerly used.

Point 3 might seem the obvious thing to do, but life tests or field service tests are often slighted in the desire to get the product on the market. One manufacturer of kitchen furniture did not turn out the best possible product until he began subjecting the finish on his tables to such things as lemon juice, vinegar, ketchup, milk, and other liquids that might attack the finish. These practical tests quickly led to the adoption of the one finish that would stand up longest under severe service conditions.

—Carl Heyel
New York, N. Y.

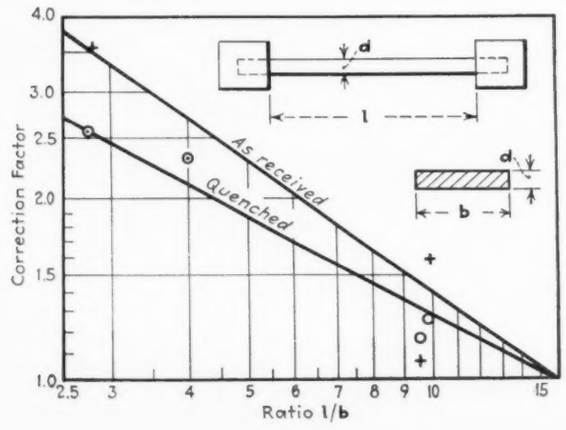


Fig. 1 — Correction factors for the effect of length on torsional specimens

Spring Ring Stresses

● One method of stress analysis for split rings, applicable to the problem contributed by J. A. Hall on page 229 in the June number, gives an approximate solution to the general case. The change in radius of curvature is:

$$R_l - R = \frac{MR^2}{EI + MR} \qquad (1)$$

In this relation,

R = radius of curvature free
R_l = radius under load
M = bending moment at any section
E = elastic modulus
I = moment of inertia of normal section

Both M and I may be expressed in terms of the known constants and some parameter such as the angle ϕ shown in the accompanying diagram. For small loads, the moment at any point q for a half-gap h and the load P in lb. is:

$$M = P\,(\sqrt{R^2 - h^2} + R\cos\phi) \qquad (2)$$

If t is the radial thickness of the spring, b its maximum width, and a

the change in width per radian of angle ϕ, then I, the moment of inertia is,

$$I = \frac{t^3}{12}(b - a\,\phi) \qquad (3)$$

Being symmetrical, only one half of the spring need be considered. Dividing the whole angle between the point a and the end of the spring g into increments and taking any arbitrary value for P, changes of radius of curvature are calculated by substituting in Equation (1) values obtained from Equations (2) and (3) given above.

Starting on the axis of symmetry as shown in the diagram, the distance OC is the increase in radius of curvature for the section ab when the load P is applied. Similarly the distance $O\text{-}m_1$ is the increase in radius for the arc bc, and so on. The locus of points m_1 to m_7 delineates the change of radius of curvature at any angle.

Any point b on the original circle, after some deflection will have a new position b' on the elastic axis. Assuming no peripheral change of length, and the deflected shape circular, the segment ab' may be taken as an arc around point C with aC as the radius. The angle subtended by ab' is the angle aOb multiplied by aO/aC.

For the next segment $b'c'$, the radius of curvature is the distance bm_2, which measured along the line $b'C$ gives the point n_2 for the center of the arc $b'c'$. The position of c' along the arc is such that the angle aOb multiplied by bO/bm_2 defines the arc.

This construction is repeated until g has been located as g', giving the curve ag' as first approximation to the elastic axis. The points n_2 to n_6 are the locus of the evolute. The scale of the whole layout is set by numerical values for the differences in curvature.

The deflection of the spring has changed both the magnitude and the distribution of bending moment from that initially assumed. The moment arms at q' is not the same as that at q hence the bending moment applied must be adjusted in the ratio $q'g'/qg$ measured parallel to the axis of symmetry. Hence the difference in radii of curvature also must be altered.

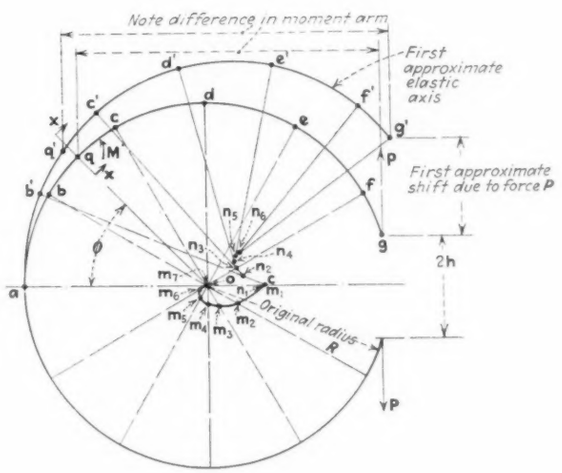
A second spiral, not shown in the diagram, is constructed with radial coordinates similarly increasing. The distance Om_1 is multiplied by ag'/ag and distances Om_2 to Om_6 multiplied by $b'g'/bg$, and the angle values correspondingly changed, and so on. This adjustment follows the procedure outline above.

By taking aribtrary values of P a rate curve may be approximated, and a plot made of stress S versus P. Using adjusted values of M, the stress at any point closely approximates

$$S = Mt/2I \qquad (5)$$

This approximate method shows the events that occur, may be used to investigate snap rings of either the "snap-in" or "snap-on" type, and is useful in comparing deformed shapes and assembly inferences.

—Roland V. Hutchinson
Lansing, Mich.



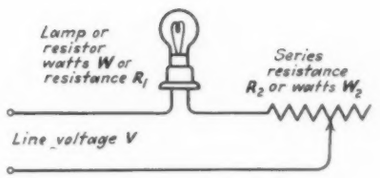
First approximation to the elastic curve of a split circular ring loaded by opposing forces at the gap

Reducing Wattages

STILES BEGGS
Rochester, N. Y.

● When it is desired to reduce the heat output of an electric heater or lamp, resistance can be inserted in series with the heater. With no resistance in series, W_0 the watts consumed by the heater in terms of the line voltage V and the heater resistance R_1 in ohms, is given by,

$$W_0 = V^2/R_1$$



From equations given by Mr. Beggs, reductions in heater wattage can be calculated for added series resistance

By inserting a given resistance R_2 in series with the lamp or heater increases the total resistance to $(R_1 + R_2)$. For a given voltage the wattage is inversely proportional to the square of the resistance in the circuit, as can be seen from the above equations. Hence,

$$W = W_0\left(\frac{R_1}{R_1 + R_2}\right)^2$$

For the required resistance to be put in series for a given reduced wattage the above equation is solved for R_2, giving,

$$R_2 = R_1\left(\sqrt{W_0/W} - 1\right)$$

To prevent overheating, the rated wattage W_2 of the inserted resistance should not be less than,

$$W_2 = \sqrt{WW_0} - W$$

Rated wattages for heaters and lamps are based on the specified line voltage and the actual wattage will be charged with the line voltage.

Tight Setscrews

To the Editor:

● One factor in favor of hollow and socket-head screws given in the article on page 130 of the April number is that since they do not project, there is less disturbance of balance in setting high-speed pulleys or other rotating parts.

Improvements that will eventually find their way into practice will make it unnecessary to pull up a setscrew tightly. A screw for attaching a pulley to a 1-in. shaft, for instance, might have a short dog point about $\frac{1}{8}$ in. long, with a hole drilled in the shaft to receive the point with a tight fit. A special seating tool could do the drilling after the pulley or other part is in place. This tool could be a combination of screw and drill, making use of the thread to obtain pressure on the drill and having a length just sufficient for the required hole depth against which the point will beat.

—John E. Hyler
Peoria, Ill.

Thermostatic Mechanisms—III

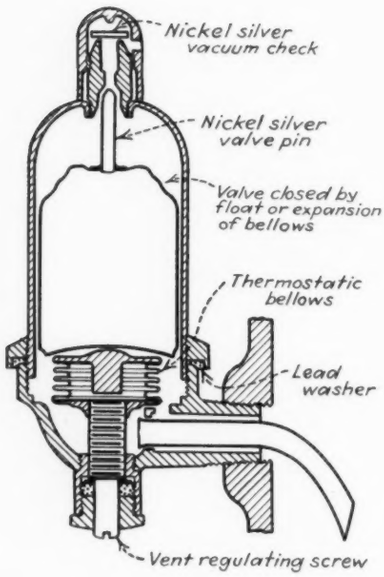


FIG. 15

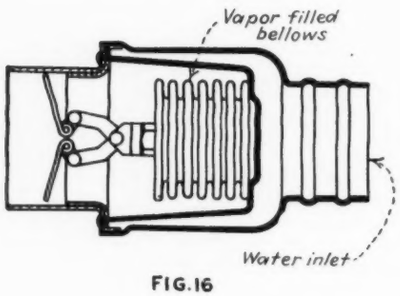


FIG. 16

TWO PRECEDING articles, in this series of three, described thermostatic mechanisms operated by bimetal elements. The controls shown here are actuated by the expansion of vapor, gas or liquid contained in flexible bellows.

Fig. 15—In radiator air valves made by the Anderson Manufacturing Company, air forced into the valve passes around a small bellows partially filled with a liquid. When steam reaches the valve, the heat increases the vapor pressure within the bellows, and the resultant expansion raises the float, thereby closing the air vent orifice.

Fig. 16 — Automobile cooling water temperature is controlled by a self-contained bellows in the thermostat made by the Bridgeport Brass Company. As in the radiator air valve, the bellows itself is subjected to the temperature to be controlled. As the temperature of the water increases to about 140 deg. F., the valve starts to open; at approximately 180 deg. F. free flow is permitted. At intermediate temperatures the valve opening is in proportion to the temperature.

Fig. 17—In a throttling type of circulating water control valve made by C. J. Tagliabue Manufacturing Company for use in refrigeration plants, the valve opening varies with the pressure on the bellows. This valve controls the rate of flow of the cooling water through the condenser, a greater amount of water being required when the temperature, and therefore the pressure, increases. The pressure in the condenser is transmitted through a pipe to the valve bellows thereby adjusting the flow of cooling water. The bronze bellows is protected from contact with the water by a rubber diaphragm.

Fig. 18—An automatic gas range control made by the Wilcolator Company has a sealed thermostatic element consisting of a bulb, capillary tube and bellows. As food is often placed near the bulb, a non-toxic liquid, chlorinated diphenyl, is used in the liquid expansion system. The liquid is also non-inflammable and has no corrosive effect upon the phosphor bronze bellows. By placing the liquid outside instead of inside the bellows, the working stresses are maximum at normal temperatures when the bellows bottoms on the cup. At elevated working temperatures, the expansion of the liquid compresses the bellows against the action of the extended spring which in turn, is adjusted by the knob. Changes in calibration caused by variations in ambient temperature are compensated by making the rocker arm of bimetal suitable for high temperature service.

Fig. 19—For electric ranges the Wilcolator thermostat has the same bellows unit as is used on the gas-type control. But, instead of a

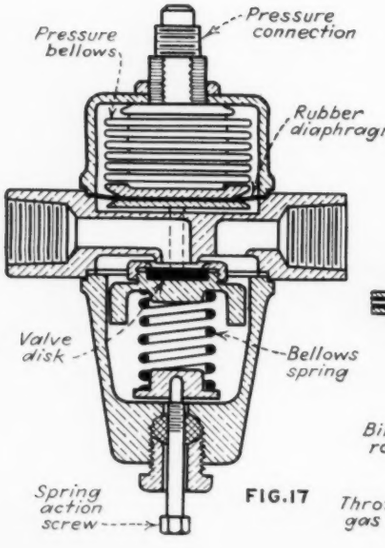


FIG. 17

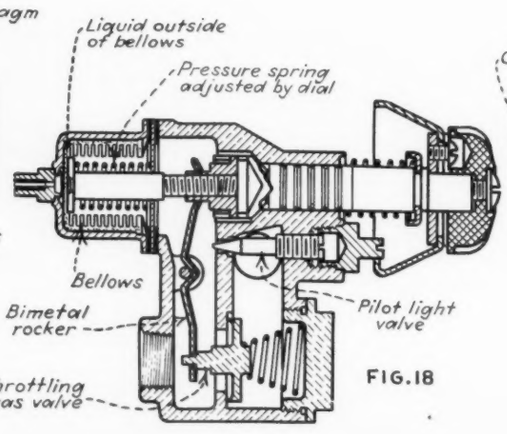


FIG. 18

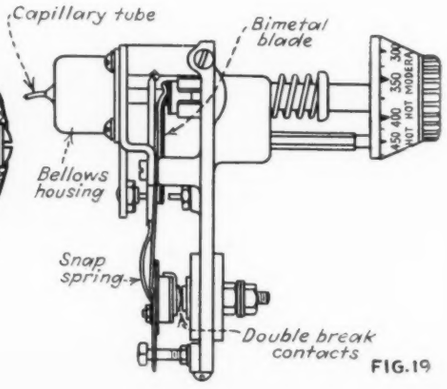


FIG. 19

throttling action, the thermostat opens and closes the electrical contacts with a snap action. To obtain sufficient force for the snap action the control requires a temperature difference between "on" and "off" positions. For a control range from room temperature to 550 deg. F., the differential in this device is plus or minus 10 deg. F.; with a smaller control range, the differential is proportionately less. The snap action switch is made of beryllium copper, giving high strength, better snap action and longer life than obtainable with phosphor bronze, and because of its corrosion resistance the beryllium-copper blade requires no protective finish.

Fig. 20—For heavy duty room temperature controls, the Penn thermostat uses a bellows mechanism that develops a high force with small changes in temperature. The bronze bellows is partially filled with butane, a liquid having a large change in vapor pressure with changes in temperature in the range of room temperatures. Snap action of the electrical contact is obtained from a small permanent magnet that pulls the steel contact blade into firm contact when the bellows cools. Because of the firm contact, the device is rated at 20 amp. for non-inductive loads. To avoid chattering or bounce under the impact delivered by the rapid magnetic closing action, small auxiliary contacts are carried on light spring blades. With the large force developed by the bellows, a temperature differential of only 2 deg. F. is obtained.

Fig. 21—Snap action in the Tagliabue refrigerator control is obtained from a bowed flat spring. The silver contacts carried on an extended end of the spring open or close rapidly when movement of the bellows actuates the spring. With this snap action the contacts can control an a.c. motor as large as 1½ hp. without the use of auxiliary relays. Temperature differential is adjusted by changing the spacing between two collars on the bellows shaft passing through the contact spring. For temperatures used in freezing ice, the bellows system is partially filled with butane.

Fig. 22—In the General Electric refrigerator control, the necessary snap action is obtained from a toggle spring supported from a long arm moved by the bellows. With this type of toggle action the contact pressure is a maximum at the instant the contacts start to open. Thermostatic action is obtained from a vapor-filled system using sulphur dioxide for usual refrigerating service or methyl chloride where lower temperatures are required. To reduce friction, the bellows makes point contact with the bellows cup. Operating temperature is adjusted by changing the initial compression in the bellows spring. For resistance to corrosion, levers and blades are stainless steel with bronze pin bearings.

Fig. 23—Two bellows units are used in the Fedders thermostatic expansion valve for controlling large refrigeration systems. A removable power bellows unit is operated by vapor pressure in a bulb attached to the evaporator output line. The second bellows serves as a flexible, gas-tight seal for the gas valve. A stainless steel spring holds the valve closed until opened by pressure transmitted from the thermostatic bellows through a molded push pin.

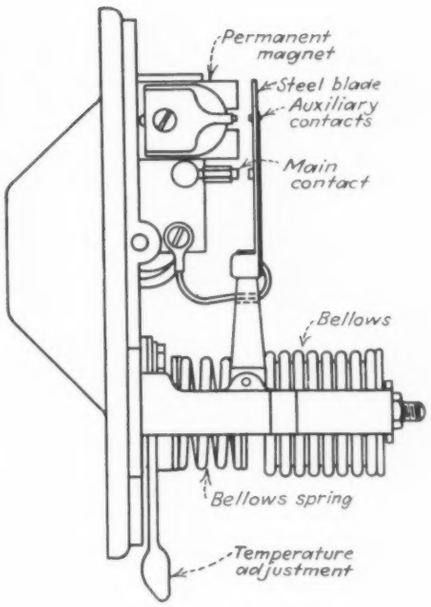


FIG. 20

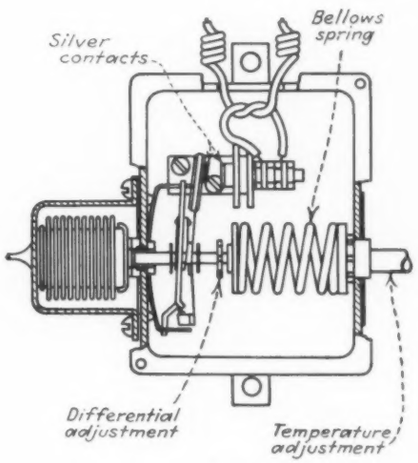


FIG. 21

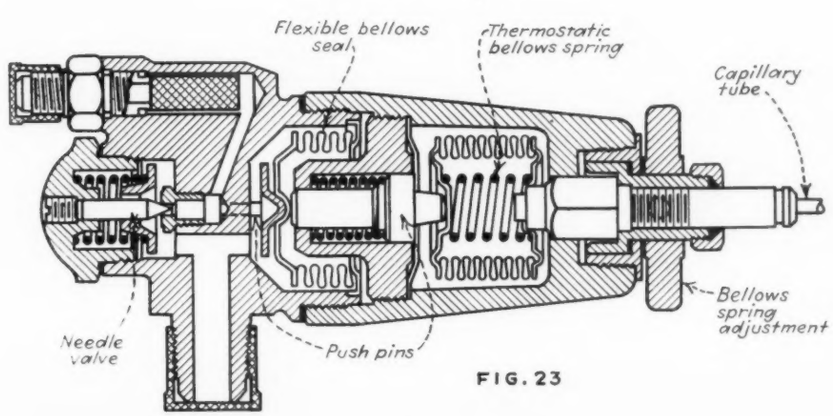


FIG. 23

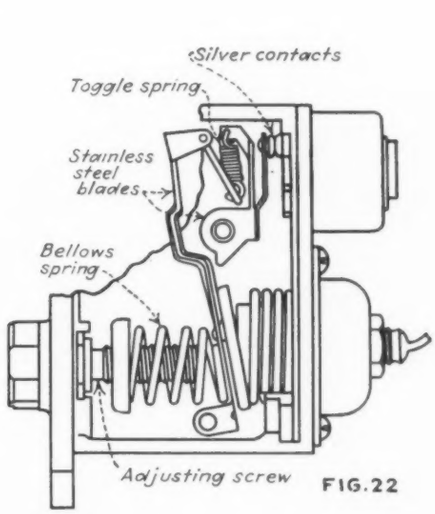


FIG. 22

NEWS

Machine Tool Show Largest Ever Held

DESCRIBED as the mightiest pageant of machines and shop tools in history, the Machine Tool Show will open its doors in Cleveland, Ohio, on September 11. Continuing until September 21, the biggest array of metal working machinery that has ever been gathered under one roof will be on exhibition. It is heralded to be the largest industrial exposition of any kind ever held in the United States. All types of metal fashioning machinery will be seen, including welding machines and equipment, small portable tools, machine tool parts and units, and a great variety of shop equipment.

Concurrent with the Machine Tool Show will be held the sessions of the Machine Tool Congress in which the nation's foremost authorities on machine tool design, construction and use will participate. On the evening of the opening day, September 11, the Machine Shop Practice Division of the American Society of Mechanical Engineers will hold a session at which two papers on surface finishing by grinding will be presented. Mr. Howard W. Dunbar, manager of the Grinding Machine Division of the Norton Co., will present a paper on "Surface Finishing by Cylindrical Grinding." At the same session, presided over by Mr. Philip E. Bliss, president of the Warner & Swasey Company, Mr. A. W. Schneider of the Heald Machine Co., will present a paper, "Internal Surface Finishing."

On Thursday evening, the Machine Shop Practice Division of the A.S.M.E. will hold an informal dinner at the Hotel Statler in Cleveland. At the dinner, Mr. Kenneth H. Condit, editor of *American Machinist* will give an informal talk on "Machine Shops in Nazi Germany." Following this there will be a technical session at which Mr. Roger D. Prosser will present a paper "Cemented Carbide Cutting Material," to be followed by a talk illustrated with moving pictures, "Chip Formation Under the Microscope, As Recorded by the Motion Picture Camera," by Hans Ernst of the Research Department of the Cincinnati Milling Machine Company.

Another technical session on Friday, Sept. 15, will be under the auspices of the American Society of Tool Engineers and on Wednesday, September 18 the Society of Automotive Engineers will hold a technical session.

Attention is called to the fact that membership in the Machine Tool Congress or any of the participating societies carries with it the privileges of reduced rate railway fares. Individuals planning to attend this congress are urged to write to the Machine Tool Congress at 1220 Guarantee Title Bldg., Cleveland, Ohio, to procure certificates to be presented to the railroad agent when purchasing transportation for the congress. Company memberships in the Congress cost $5; individual membership, $1.

The two earlier Machine Tool Congresses of 1927 and 1929 established criteria of the highest practical and technical importance. It was at the 1929 Congress, for example, that the first American paper on the development of tungsten carbide tools was read. The program of the Machine Tool Congress of 1935 will be of surpassing interest to all industrial executives visiting the Machine Tool Show.

Electro-Deposited Fine Mesh Screens

PRODUCTION of smooth surface, fine mesh, flat metal screens on a commercial scale by electrolytic deposition has been announced by the Electrolytic Products Corporation. These screens can be made in meshes as fine as 400 holes per linear inch, that is, 160,000 holes per sq.in. Even finer mesh screens can be made if required.

Whereas woven wire screens are rough and the size of the holes is more or less fixed for any given mesh, these new type screens are flat and smooth and the size of the hole for a given mesh can be varied between wide limits. As an example, a 120 mesh woven wire cloth ordinarily has an opening of approximately 0.0045 in., whereas 120 mesh screen made by this electro deposition method may have holes as large as 0.006 in., if desired, or the hole may be as small as 0.001 in. or even less. Generally speaking, the hole can be made as small as desired irrespective of the mesh, but for any given mesh the maximum size of hole is limited to approximately 75 per cent of the center distance of the holes. For example, on a 120 mesh screen the center distance of the holes is 0.0083 in. The maximum size hole that can be produced economically in screens made by this electrolytic deposition process will be 75 per cent of 0.0083 in., or 0.0062 in. approximately.

Normally, these smooth surface screens are manufactured with a circular hole, but the shape of the hole can be controlled to a considerable extent. Thus holes that are approximately square openings can readily be furnished and likewise holes of any desired pattern can be simulated, if not produced exactly.

For the majority of applications, the thickness of these new type screens ranges from 0.002 in., to 0.003 in., such thickness generally resulting in greatest economy. Screens thicker than 0.003 in. can be supplied in practically all meshes except the extremely fine mesh.

It is reported that these screens made by electrolytic deposition have already been used successfully for photo-engraving work. They also possess desirable acoustic properties which has made them suitable for use on certain high grade telephone transmitters, and broadcast transmitters, and also for "pick-up" devices. They are suitable for any application involving sifting or straining, either solids or liquids, the absence of cross wires and the readiness with which they can be cleaned makes these screens specially suitable for such applications.

It is claimed that the cost of these smooth surface screens will in most instances compare favorably with that of woven wire cloth, especially in the finer meshes. The production methods are such that there is not so much variation in cost between the coarse mesh and the fine mesh screen. They can be made in pure nickel, copper, or brass, or any other metal that can be deposited electrolytically.

Urge Adoption of Drawings Standard

WITH the "American Standard Drawings and Drafting Room Practice" now available in printed form, (American Standards Association, 29 West 39th Street, New York, N. Y. Price 50 cents), manufacturing companies are being urged to accept and put into effect these standards in order that there may be a uniform drafting practice throughout the United States.

In general, this standard code follows the prevailing practice as indicated by the majority of votes on the questionnaires and the approvals of preliminary reports submitted to the leading manufacturing companies. Consequently, only in rare instances will it be found that the standard deviates widely from that in use by any one company.

As pointed out by the committee that drew up the standards, whenever a definite majority prefers one method and the balance is made up of many small minorities, it may generally be assumed that the best practice is that of the majority. When two or more methods have nearly the same number of followers, the one coming into increasing use by progressive firms has been given preference over one declining in use.

The committee has recognized that a good many companies will be reluctant to change from some methods they may be using to another which to them seems to be no better. But, it is hoped that in the interest of uniformity the adopted standard method of representation may be acceptable to such manufacturers in spite of their individual preference. Only by such concessions can a standard practice become a reality.

More than 900 companies interested in engineering drawing practice were invited to submit data, the work of the committee being divided among six sub-committees and the S.P.E.E. Division on Engineering Drawings. The reports of several of the national standardizing bodies of foreign countries were studied. To complete the code and prepare it for publication required more than 9 years of work.

New Glass Bends Like Steel

GLASS that will bend like a sheet of steel is the latest product of the flat glass industry. Although the industry is not quite ready to produce it in large volume, this new glass has already been put to use in a number of places. It is described as the world's hardest glass, its characteristic properties being produced by heat-treatment in a new electric furnace designed in England. The Libbey-Owens-Ford Glass Company of Toledo is one of two companies licensed to use the process in the United States and in its plant at Ottawa, Ill., is installing two of the English furnaces.

The treatment consists of placing a sheet of ordinary plate glass in the furnace and heating it until it is plastic. Then a blast of cold air is suddenly directed against the glass which develops high compression stresses on the outer wall of the glass, while the interior is under tension. This gives the glass a strength from four to six times that of ordinary glass. It will support a great weight, can be twisted or bent and will resist breakage to an unbelievable degree. It is breakable, of course, when extraordinary force is brought to bear, but when it does break the glass crumbles into small fragments like rock candy. And the pieces do not cut or scratch like ordinary slivers of glass.

Wherever heat affects glass, this new glass may be used. In Libbey-Owens-Ford's own Charleston plant, for instance, where windows in some of the furnaces are exposed to terrific heat inside and only 70 deg. F. outside, replacements had to be made frequently until the new processed glass was used.

Research engineers, to demonstrate some of its qualities, place a sheet of the treated glass on a cake of ice and then pour hot lead on the glass surface. Despite this extreme test, the glass does not crack.

Its possibilities in the automotive industry, in building and construction activities and in other fields where glass is subjected to unusual daily rough usage, are interesting and endless.

MEETINGS

American Society of Mechanical Engineers—Machine Shop Practice Division, Hotel Statler, Cleveland, Ohio. Sept. 11-12. C. E. Davies, secretary, 29 West 39th St., New York, N. Y.

National Metal Congress—Palmer House, Chicago, Ill. Sept. 30-Oct. 4, the following societies participating:

American Institute of Mining and Metallurgical Engineers—John T. Breunich, assistant secretary, 29 West 39th St., New York, N. Y.

American Society for Metals — W. H. Eisenman, secretary, 7016 Euclid Ave., Cleveland, Ohio.

American Welding Society—Miss M. M. Kelly, secretary, 29 West 39th St., New York, N. Y.

EXHIBITIONS

National Electrical and Radio Exposition — Grand Central Palace, New York, N. Y., Sept. 18-28. Ralph Neumuller, managing director, Grand Central Palace, N. Y.

National Metals Exposition—International Amphitheater, Chicago, Ill., Sept. 30-Oct. 4. W. H. Eisenman, general manager, 7016 Euclid Ave., Cleveland, Ohio.

National Automobile Show — Grand Central Palace, New York, N. Y., Nov. 2-9. Alfred Rieves, manager, 366 Madison Ave., New York, N. Y.

New FHA Loan Plans Spur Product Design

IT IS expected that the extension of the National Housing Act to include provisions to help finance the modernization and improvement of business properties and manufacturing plants will have far reaching effects. Formerly only applicable to the modernization and improvement of dwellings, a recent amendment to the National Housing Act now provides that the Federal Housing Administration may now insure loans up to $50,000 for the modernization and improvement of business and industrial plants. Such loans may be applied to cover repairs, alterations and improvements, including the cost of architectural services, to buildings and to the purchase and installation of such machinery and equipment as is essential to the business conducted upon the property to be improved. Production machinery of all kinds is included, the Federal Housing Administration insuring the loans covering the purchase of such equipment for a period not in excess of 5 years, repayment of the loans to be made out of current income without impairment of capital.

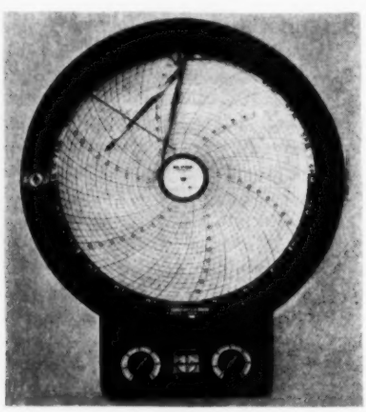
It is pointed out that the modernization of manufacturing machinery and equipment will not only create further activity in the machine-tool industry, but will also spur designing activities in the plants modernized. With up-to-date machinery available for manufacturing, in many instances it will be necessary to completely redesign the product manufactured in order that fullest advantage may be taken of the manufacturing economies inherent in the new machines.

In numerous plants the product manufactured still adhered to an obsolete and uneconomical type of design and construction. This is largely accounted for by the inability of the manufacturer to finance the cost of new equipment that would be necessary to manufacture a product designed according to newly developed types of construction. With the new method of financing now available, new equipment can be purchased, the old product redesigned, and in some instances a completely new line of products might be developed.

New Materials and Parts

Air Operated Controllers

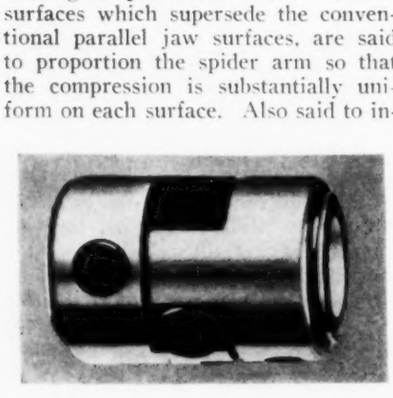
For indicating temperature, flow, pressure, and liquid level. These "Air-O-Line" controllers have an adjustable throttling range of 1 to 150 per cent and automatic reset. Indicating and recording temperature controllers within limits of —40 deg. F. and 1,200 deg. F. and potentiometer-type controllers within limits of —300 deg. F. and 3,400 deg. F. are available. Two types of flow controllers and liquid level controllers of the inductance bridge and mechanical types are offered. Indicating and recording

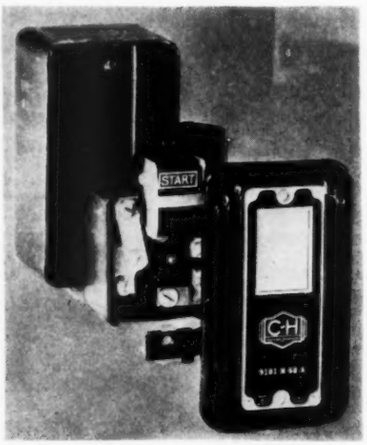


pressure controllers in ranges from 30 in. vacuum to 3,000 lb. pressure per sq.in. are also available. Brown Instrument Co., Wayne & Roberts Aves., Philadelphia, Pa.

Flexible Coupling

Type IA coupling has convex jaw surfaces that exert rolling pressures on bearing or spider arms. These convex surfaces which supersede the conventional parallel jaw surfaces, are said to proportion the spider arm so that the compression is substantially uniform on each surface. Also said to increase life of cushioning spider 50 per cent. Available in standard sizes 1/12 to 200 hp. at 1,750 r.p.m., $\frac{1}{4}$ to 3 in. diameter bore. Lovejoy Tool Works, 5019 West Lake St., Chicago, Ill.



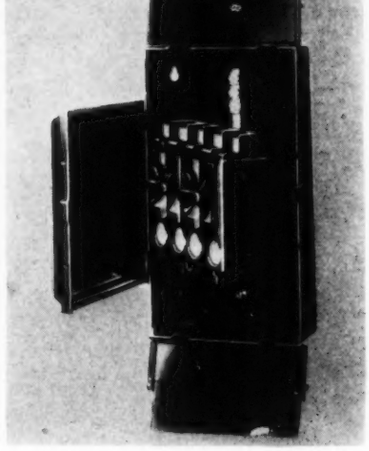


Motor Starter

Is used for fractional hp. applications. Switch is protected against overloads with a free-tripping thermal overload mechanism. An overload is instantly indicated in the switch itself by the return of the operating button to the "off" position. One operation resets the overload mechanism and restarts the motor. Heater coil can be changed to provide protection for various sizes of motors. Switch has silver to silver "twin-break" contacts, removable mechanism for ease of wiring, non-rusting mechanism and stainless steel springs. Cutler-Hammer, Inc., 12th & St. Paul Ave., Milwaukee, Wis.

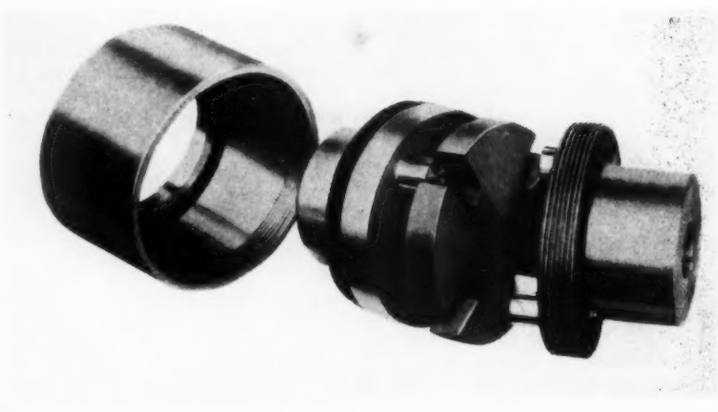
Range Switch

With swing-out interior to facilitate wiring. Equipped with dead front fuse puller. Fuses are ventilated by means of large openings in the light bakelite cover. Fuse clip and contact blade are made in one piece. Jaws are recessed below surface of block to prevent danger of accidental contact with live parts. No pressure is extended on ferrule when fuse puller is removed. Square D Co., Detroit, Mich.



Flexible Coupling

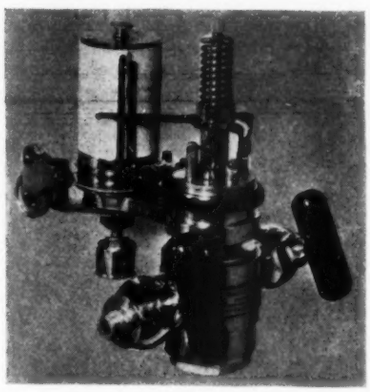
Is self-adjusting to compensate for either parallel or angular misalignment. Coupling is made in four parts, having a driving and driven hub with round pin driving members, a floating



disk made of bone fiber with recesses for the driving pins and a cover housing which screws on the driven disk, inclosing the working parts. Said to drive readily with a $\frac{1}{8}$ in. parallel misalignment and up to 6 deg. angular misalignment and to operate noiselessly. Alloy Products Corp., Waukesha, Wis.

Differential Pressure Recorder

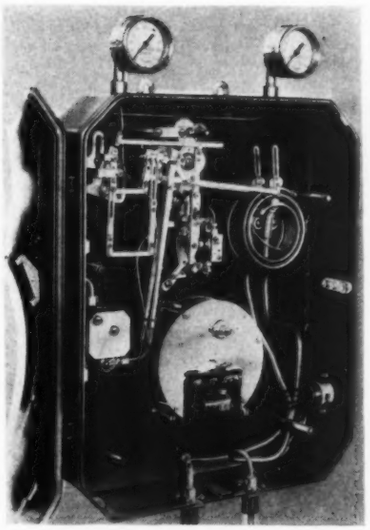
Piston type recorder for measuring and recording rapidly fluctuating pressures on either side of a piston or reciprocating oil pump, for the study of sudden or constantly changing differential pressures of small magnitude at high static pressures or for determination of the pressure drop between two points of measurement under rapid fluctuations. Clock-works are available for chart speed of 7 to 72 in. per min., 10 to 100 ft. per min., and 150 to 450 ft. per min., it being possible to set each speed range for 4 intermediate speeds. Standard recorder can be adapted to any pressure range up to



2,000 lb. per sq. in. Higher ranges available with special construction. Bacharach Industrial Instrument Co., 7000 Bennett St., Pittsburgh, Pa.

Reset Controller

Controls a temperature, pressure, rate of flow or liquid level in a predetermined relation to some other temperature, pressure, rate of flow or liquid level. Can be used on all applications where a fixed differential must be maintained between two variables, one of which is under control, or where it is desirable to change the control point of a process in accordance with a predetermined ratio to a secondary process or condition. Employs one complete "Fulscope" control system and an extra tube system,



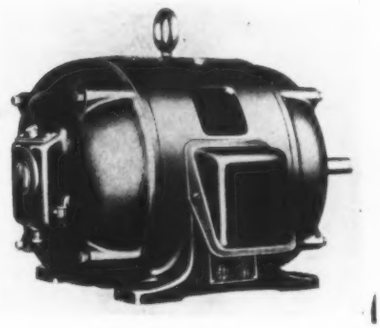
pressure spring or gage depending on the application. Direct or inverse ratio adjustments are possible. When used for temperature applications, actuation can be by mercury, vapor or gas. Chart is rotated by electrically or spring driven clocks. Control maintained by air pressure to a diaphragm valve with a constant 25-lb. per sq.in. pressure. Available in die-cast aluminum, black or white case, for face or flush mounting on panel boards. Taylor Instrument Companies, Rochester, N. Y.

Felt Protected Ball Bearings

Three larger sizes having 40, 45 and 50 m.m. bore has been added to the line of "GreaSeal" felt-protected precision ball bearings. The removable felt seals consist of thick close fitting felts between removable plates, forming a labyrinth seal against the inner ring. These seals, being in the confines of both rings, are not exposed to injury. Available in three series, "7000" having a single seal; "7000-P" with single seal and plate shield; and "77000" with double felt seal. The two latter series are fully inclosed for retention of lubrication and exclusion of dirt and moisture. Norma-Hoffmann Bearings Corp., Stamford, Conn.

Normal and High Torque Motors

Squirrel cage, induction, polyphase motor especially designed for refrigeration and air-conditioning applications. It is said that special attention has been paid to mechanical stability by including a cast frame and end brackets, ample sized shafts and bearings and well anchored field and rotor cores. Electrolytic copper bars and end rings are so joined as to form an homogeneous high-conducting joint. It is claimed that this line gives a composite performance of torque, efficiency, power factor and quiet operation. Available with sleeve or ball bearings in sizes of 600 hp. and smaller. Century Electric Co., 1806 Pine St., St. Louis, Mo.

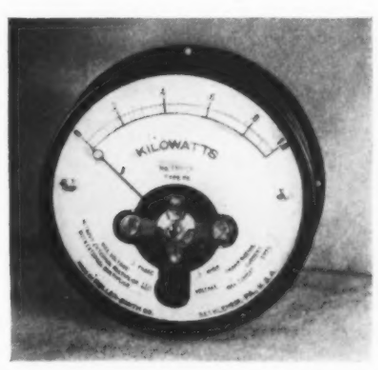


Thiokol D

An oil-proof synthetic rubber having a tensile strength of 1,700 lb. per sq.in., and an elongation of approximately 500 per cent. Said to be abrasion resistant, to be flexible at —45 deg. F., and to withstand oil at 200 deg. F. In addition to being oil-proof, it is claimed to offer exceptional resistance to lacquers and thinners, printing inks, benzo-gasoline blends and most of the ordinary solvents. Has good aging qualities and unobjectionable odor. Thiokol Corp., Yardville, Trenton, N. J.

Polyphase Wattmeter

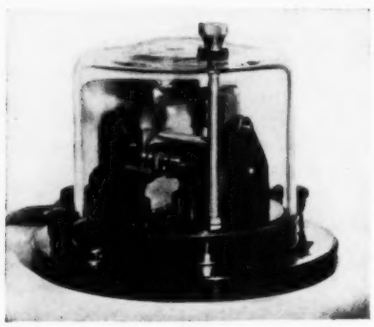
A 4-in. wattmeter for semi-flush panel mounting. The mechanism is of a full two element polyphase type, and rated at 5 amp. for potentials up to 600 volts. Body is $4\frac{1}{8}$ in. diam., having a length of $4\frac{3}{4}$ in. The instru-



ment projects 1¾ in. beyond the front of the panel. The recording scale is 2¾ in. long. This new device matches the appearance of a line of a.c. and d.c. ammeters and voltmeters manufactured by Roller-Smith Co., 233 Broadway, New York, N. Y.

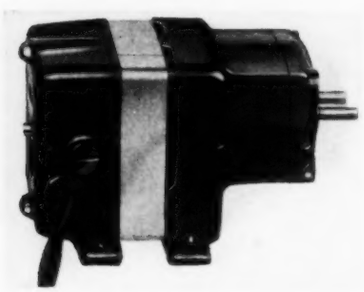
Mercury Relay

Improved design of the "Aminco" supersensitive relay for use with mercury thermo regulators and other devices with delicate contacts. A flexure plate is used in place of an armature pivot. The relay can be changed from "normally open" to "normally closed" by exchanging the position of two screws. Relay operates on 0.007 amp., at 6 volts d.c. Mercury tube contacts are rated at 10 amp. for 115 volts a.c. or 2 amp. at 115 volts d.c. Diameter of base is 5½ in. and the relay is 4⅜ in. high. American Instrument Co., Inc., 774-776 Girard St., N.W., Washington, D. C.



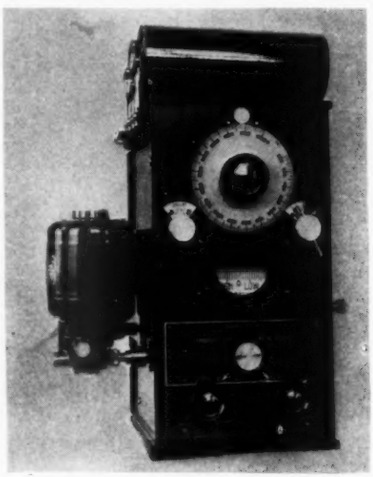
Small Back-Geared Motor

Is incased in cast steel end bells, the induction type being air-cooled with a small rotary blower. Operates on a.c. and d.c., 110 volts. The built-in gear box permits various speed combinations for two shafts which can have different speeds. Feet provided for horizontal or vertical mounting. The motor is 3x3x3½ in. in size and weighs 3 lb., having 15 watts output. Motors available for induction or series wound. Speedway Mfg. Co., 1834 S. 52d Ave., Cicero, Ill.



Improved Drive for Control Pyrometers

Motor drive units for installations where potentiometer control pyrometers are used singly. The drive consists of a ball bearing inclosed motor with built-in double worm and gear speed reducer. The drive is amply powerful to operate one additional controller by means of a coupling between controllers. The Foxboro Co., Foxboro, Mass.

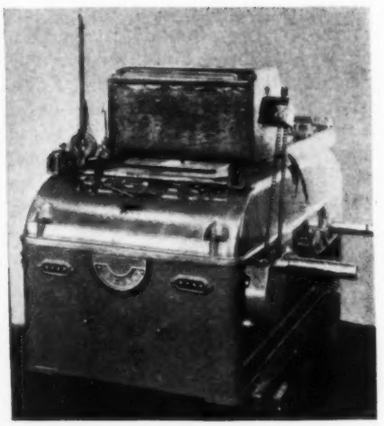


Non-Bleeding Plastic Material

To overcome bleeding of the dye in molded plastic parts exposed to acetone or other strong solvents or acids, "Durez 3973 Black" has been developed. This material has a low moisture rate of 0.7 per cent and withstands a compressive load of 30,000 lb. per sq.in. Used in textile and chemical plants where action of solvents proves troublesome. General Plastics, Inc., North Tonawanda, N. Y.

Hydraulic Control for Variable-Speed Transmission

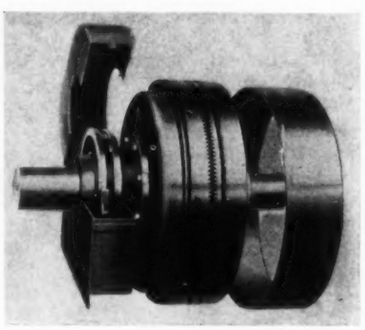
For automatically regulating the speed of a variable-speed transmission. The control is actuated by an indicating lever connected by a cable, arm, link or chain to a compensating or floating roll, or any moving part of the machine from which the indication of the required speed can be taken. The lever, through this linkage, operates the shifting levers in the transmission through a differential mechanism. All operating parts except the drive motor are housed in the



dust-proof cast iron inclosure and mounted on top of the transmission case. Either a.c. or d.c. motors can be used. Reeves Pulley Co., Columbus, Ind.

Magnetic Clutch Coupling

For quick and positive engagement. Contact surfaces are serrated with V-shaped teeth to make engagement certain when magnet coil is energized. These serrations are of equal depth and cut on 3 deg. surfaces. A ball pilot bearing mounted on the shaft assures correct alignment and true engagement of the serrated faces. One member can be disassembled without disturbing the other member. The magnet coil is form wound and vacuum-pressure impregnated. The slip rings and brush holders are protected by a dust-proof housing. Dings Magnetic Separator Co., Milwaukee, Wis.



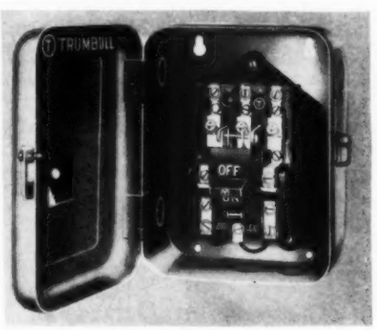
Three-Light Lamp

New inside-frosted lamp provides three different levels of illumination from a single bulb that contains two filaments of 50 and 100 watts each. These filaments can be burned individually or in combination to supply 50, 100 or 150 watts. Supplies a

higher level of illumination for difficult eye tasks than is provided in a regular 100-watt lamp and a lower level of lighting when the eyes are not engaged in prolonged or difficult work. Is equipped with a mogul, 3-contact base and is said to have a life of 1,000 hr. under average conditions of usage. General Electric Co., Nela Park, Cleveland, Ohio.

Manual Motor Starter

Type TM-7½ front operated motor starter is of across-the-line type. Has silver to silver contacts and is provided with thermostatic overload protection by interchangeable heater units. Furnished mounted in steel box provided with knockouts. Available for 1½ to 7½ hp., 110 to 550 volts, a.c., 2 and 3 poles. Also furnished for side operation in cast iron weatherproof boxes provided with gaskets for water and dust proofing. The Trumbull Electric Mfg. Co., Plainville, Conn.



"Fluid Power" Transmission

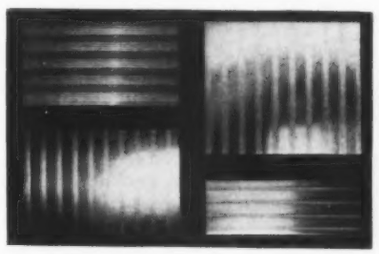
Is a multi-plunger pump for delivering hydraulic power. The discharge is infinitely variable from zero to the maximum capacity in either direction and is reversible either gradually or instantly. Speed changing, reversing or stopping are said to be easily and accurately controlled either manually, automatically, or semi-automatically by regulators. No gears, belts, electrical or other intervening mechanisms are used. May be located next to the machine served or remotely as in the manufacture of gasoline, chemicals, photographic film and explosives where a spark from an electric motor would be detrimental. The transmission can be driven by motor, turbine, belt and pulley, or engine. No packing is used in any part of the transmission, and all mechanism is inclosed in a sealed pump case said to be dust, dirt, lint, cement and flour proof. Type "HP" is capable of working pressures up to 3,000 lb. per sq.in., and type "LP" for 1,200 lb. per sq.in. pressure. American Engineering Co., Philadelphia, Pa.

Protective Coating

Plicote is used as a corrosion preventive and is said to give a hard, tenacious film that is homogeneous and flexible, and to withstand 50 per cent caustic solutions at elevated temperatures. It can be applied as a coating for brine tanks or for painting concrete floors, and is used in the canning industry for resistance to fruit and vegetable acids, being tasteless, odorless and non-toxic. The Watson-Standard Co., 225 Galveston Ave., Pittsburgh, Pa.

"Satinstripe" Strip Steel

New type of finish applied to steel strip-stock composed of stripes or patterns rolled into the steel by specially ground rolls. The design shows



clearly through after the material is chrome or nickel plated or color finished. Available in numerous kinds of stripes varying in width and depth. Acme Steel Co., 2800 Archer Ave., Chicago, Ill.

MANUFACTURERS' PUBLICATIONS

Control System—Taylor Instrument Companies, Rochester, N. Y. Bulletin 37R, 36 pages, 8½x11 in. "Dubl Response" control system for temperature, pressure, flow and liquid level. The functions of the system are portrayed photographically by two characters represented by mechanical men "First Response" and "Second Response." Pictorial diagrams are also used to illustrate the features of the double control sytem.

Conveyor Machinery — Palmer-Bee Co., Detroit, Mich. Section 107 of General Catalog 100, 64 pages, 7¼x10¼ in. Screw or spiral types of conveyors shown in application photographs, line drawings and capacity diagrams. Various driving mechanisms, couplings, channels, hangers, screws and other details also included.

Copper Alloy Steel — Inland Steel Co., 38 South Dearborn St., Chicago, Ill. Illustrated folder showing a number of applications in which copper-bearing steel is used to combat corrosion.

Electrical Products — Colt's Patent Fire Arms Mfg. Co., Hartford, Conn. Catalog 58-S, 81 pages, 8½x10¼ in. Describing various types of fusible and non-fusible safety switches and motor starters with "dualbreak" and "quadbreak" contact mechanisms and interlocking covers.

Industrial Thermometers — C. J. Tagliabue Mfg. Co., Park and Nostrand Aves., Brooklyn, N. Y. Bulletin No. 1125, 24 pages, 8½x11 in. Listing complete line of "Tag" industrial thermometers including miscellaneous metal and woodback thermometers, hygrometers, U-gages, mercurial vacuum gages and mercurial barometers. Structural features including straight, regular angle, right and left side angle and regular and reverse oblique forms are shown.

Lubricating Devices — Essex Brass Corp., 2000 Franklin St., Detroit, Mich. Catalog No. 7, 95 pages, 5x7½ in. Listing a line of sight-feed, automatic and plain lubricators, brass and glass oilers, hand oil pumps, grease cups, oil and water gages, gage and air cocks, tube fittings and other oiling devices.

Metal Stampings—Geuder, Paeschke and Frey Co., Milwaukee, Wis. Booklet, "Modern Stampings," 16 pages, 8½x11 in. Illustrating the possibilities of drawing, pressing, forming, ribbing, spinning and stamping aluminum, brass, copper, monel, steel, tin plate and zinc to which various finishes can be applied.

Power Transmission Equipment—The Medart Co., 3500 DeKalb St., St. Louis, Mo. General Catalog No. 56-T, 144 pages, 8½x11 in. Listing a com-

plete line of various types of couplings, hangers, hanger bearings and pillow blocks, clutches, pulleys, belt tighteners and rope drive accessories.

Rolled Steel—Illinois Steel Co., 208 S. LaSalle St., Chicago, Ill., and Carnegie Steel Co., Pittsburgh, Pa. Booklet "Rolled Steel for Machine Construction," 16 pages, 8½x11 in. Containing suggestions on the forms of steel available, shortcuts to economy in buying, how rolled steel and castings may be combined, information on welding technique, stress and relief. Numerous photographs show welded construction of machine beds, drums, gears, bearings, housings, and other parts.

Rubber Products—The Manhattan Rubber Mfg. Div. of Raybestos-Manhattan, Inc., Passaic, N. J. Catalog, 56 pages, 8½x11 in. General catalog of mechanical rubber products, describing belting, hose, fittings, packing, friction material, molded goods, rubber covered rolls and tanks. Design data for belting with tables and charts are included.

Safety Switches—The Electric Controller and Mfg. Co., Cleveland, Ohio. Pamphlet, 8½x11 in. Illustrated bulletin showing in detail the construction of switch. Weatherproof and dusttight, and externally operated types and various installation photographs are shown.

Solenoid Starters — Allen-Bradley Co., 1326 S. Second St., Milwaukee, Wis. Bulletin 709, 8 pages, 8½x11 in. Illustrated folder shows the principles of design of solenoid type starters having silver-alloy contacts that are opened and closed with a vertical, straight-line motion. Pictures of numerous combination switches are also shown.

Solenoid Valves—Automatic Switch Co., 154 Grand St., New York, N. Y. Booklet, "Solenoid Operated Valves," 22 pages, 8½x11 in. Use of automatic and remote control for air, gas, steam or liquids, listing various types, including safety shut-off, packless, low-pressure packed, self-sealing, rotary stem, adjustable by-pass and bellows sealed valves.

Stainless Steel Treated with Columbium — Electro-Metallurgical Co., 30 East 42nd St., New York, N. Y. Pamphlet, 8½x11 in. Showing how the addition of columbium to the austenitic type of stainless steel results in the elimination of intergranular corrosion. Data are given on the physical properties and corrosion resistance of columbium-treated steels. Welding of these steels is also discussed. Photographs of corrosion tests are shown.

Time Controls—Automatic Temperature Control Co., 34 E. Logan St., Germantown, Philadelphia, Pa. Jacket T-C containing 14 pages 8½x11 in. Describing "Positive" cycle-stop dial, cycle-repeat dial and cam operated program types of time controls, electric heat controller for furnaces, ovens and platens, with typical wiring diagrams.

Wire — Republic Steel Corp., Massillon, Ohio. Catalog Form Adv. 226-B, 40 pages, 6x9 in. Listing spring, coppered, cold heading and stainless steel wire of annealed, regular and hard drawn tempers for numerous applications.

NEW BOOKS

Drawings and Drafting Room Practice

American Standards Association, 29 West 39th St., New York, N. Y. Bulletin Z14.1, 24 pages, 8½x11 in. Paper covers. Price 50 cents.

Although for many years individual manufacturing firms have standardized their drawings and practices and have published manuals for their own use, these various practices have never been standardized throughout industry. Sponsored by the Society for the Promotion of Engineering Education and the American Society of Mechanical Engineers and approved by the American Standards Association, a graphical dictionary of drafting room practice has been agreed upon for the first time.

These standards embrace the arrangement of views, for which third angle continues to be standard. In the section of Lines and Line Work, thickness of line is given for outlines, section, hidden, center, dimension, cutting plane, break and ditto lines. Cross-sections of various materials are included. Dimensioning figures, tolerances and notations are discussed and illustrated. Screw thread representations for bolts and threaded parts are shown and trimmed sizes of drawing paper and cloth are listed. Approved specimens of vertical and inclined lettering complete these standards. The standards for graphical symbols will be presented for approval and issued as a separate publication.

American Machinists' Handbook

Colvin and Stanley. Sixth Edition, 1146 pages, 5x7 in. Red leatherboard covers. Published by McGraw-Hill Book Co., Inc., 330 West 42d St., New York, N. Y. Price $4.

The sixth edition of this well-known handbook has been revised in a number of important sections. In the 90-page chapter of Screw Threads practically all the tables, listing Class 1, 2, 3 and 4 fits have been revised to conform to the National Screw Thread Commission specifications and are more conveniently arranged than previously. These tables embody sizes and tolerances of the major, minor and pitch diameters of both the screw and the nut for the various classifications.

Likewise the section on the standards of taps has been thoroughly revised to conform to the latest findings of the Committee of the American Society of Mechanical Engineers and the American Standard Association. The new standards for self-holding or slow tapers for drills, reamers and similar tools have been incorporated. These tables include an entirely new series of drill shanks, the taper per foot being divided into three classes, according to the size of tool being used.

The handbook is divided into 26 sections under the headings among which are, screw and pipe threads, drills and taps, brazing, soldering and welding, gearing, speeds and feeds, turning and boring, grinding and lapping, punch press tools, measuring and fitting, tapers and dovetails, gages, materials and automotive and railroad shop data. A general index by sections and a cross index, the latter having 24 finely printed pages, have been completely rewritten and contain more than twice the number of subjects given in previous editions.

Engineering Drawing

5th Edition

Thomas E. French. 480 pages, 6x9 in. 804 illustrations. Gray-brown clothboard covers. Published by McGraw-Hill Publishing Co., Inc., 330 West 42d St., New York, N. Y. Price $3.

To bring this well-known textbook up to date with recently adopted standards, both the text and illustrations have been revised. Some of the chapters have been rearranged, a new chapter on sections and conventions has been included, new material added to the text, and several new tables included in the appendix.

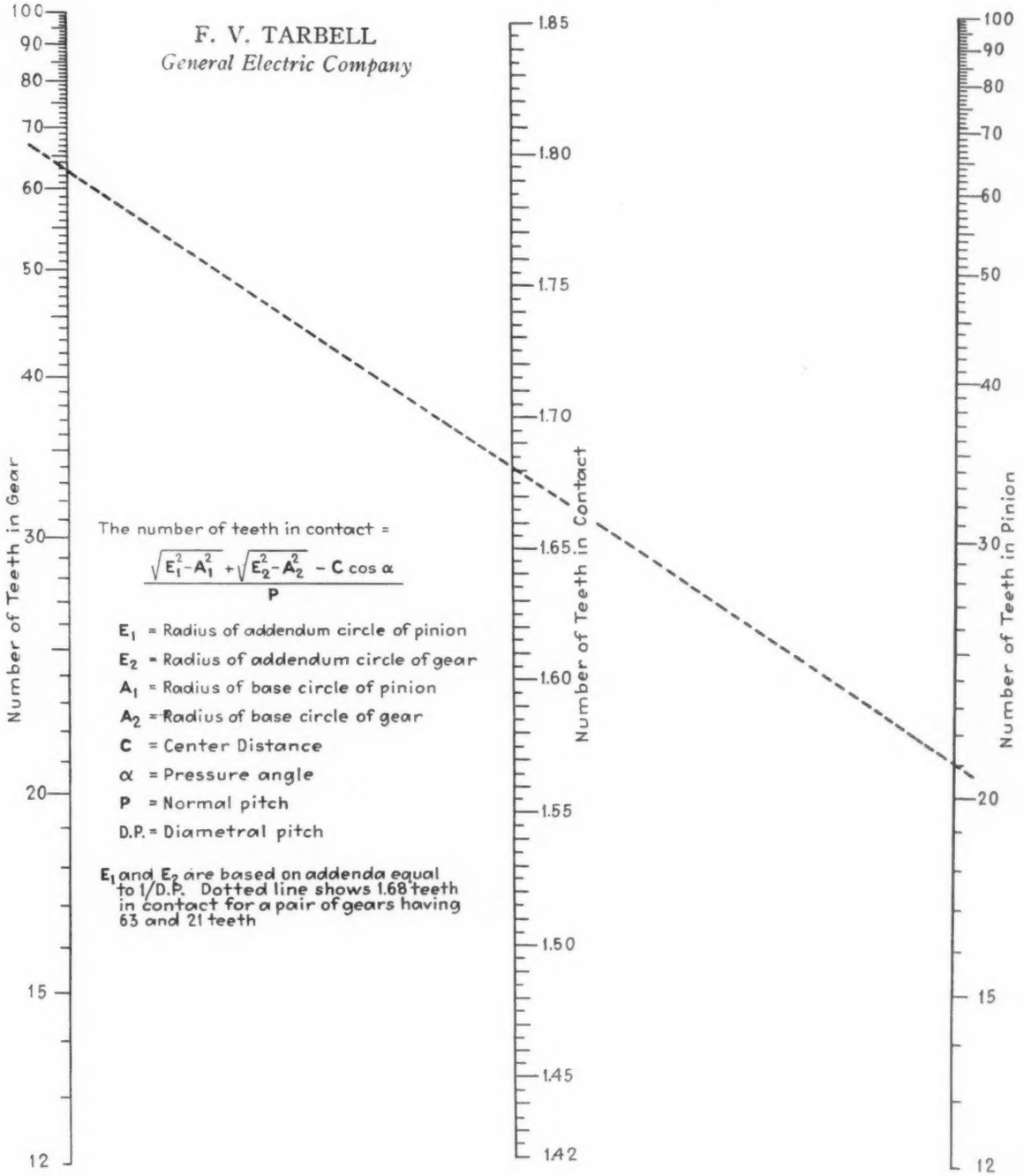
As in earlier editions, the revised text is written primarily for the engineering student, but the additional material included in this edition adds considerably to its reference value. New standards for symbols, definitions and dimensions are described in detail, and applied by the author throughout the text.

An extensive bibliography and appendix fill 32 pages; the index has been expanded to 10 pages.

Number of Teeth in Contact

Chart for a full-depth spur gear tooth having a 20 deg. pressure angle

F. V. TARBELL
General Electric Company



The number of teeth in contact =

$$\frac{\sqrt{E_1^2 - A_1^2} + \sqrt{E_2^2 - A_2^2} - C \cos \alpha}{P}$$

E_1 = Radius of addendum circle of pinion
E_2 = Radius of addendum circle of gear
A_1 = Radius of base circle of pinion
A_2 = Radius of base circle of gear
C = Center Distance
α = Pressure angle
P = Normal pitch
D.P. = Diametral pitch

E_1 and E_2 are based on addenda equal to 1/D.P. Dotted line shows 1.68 teeth in contact for a pair of gears having 63 and 21 teeth

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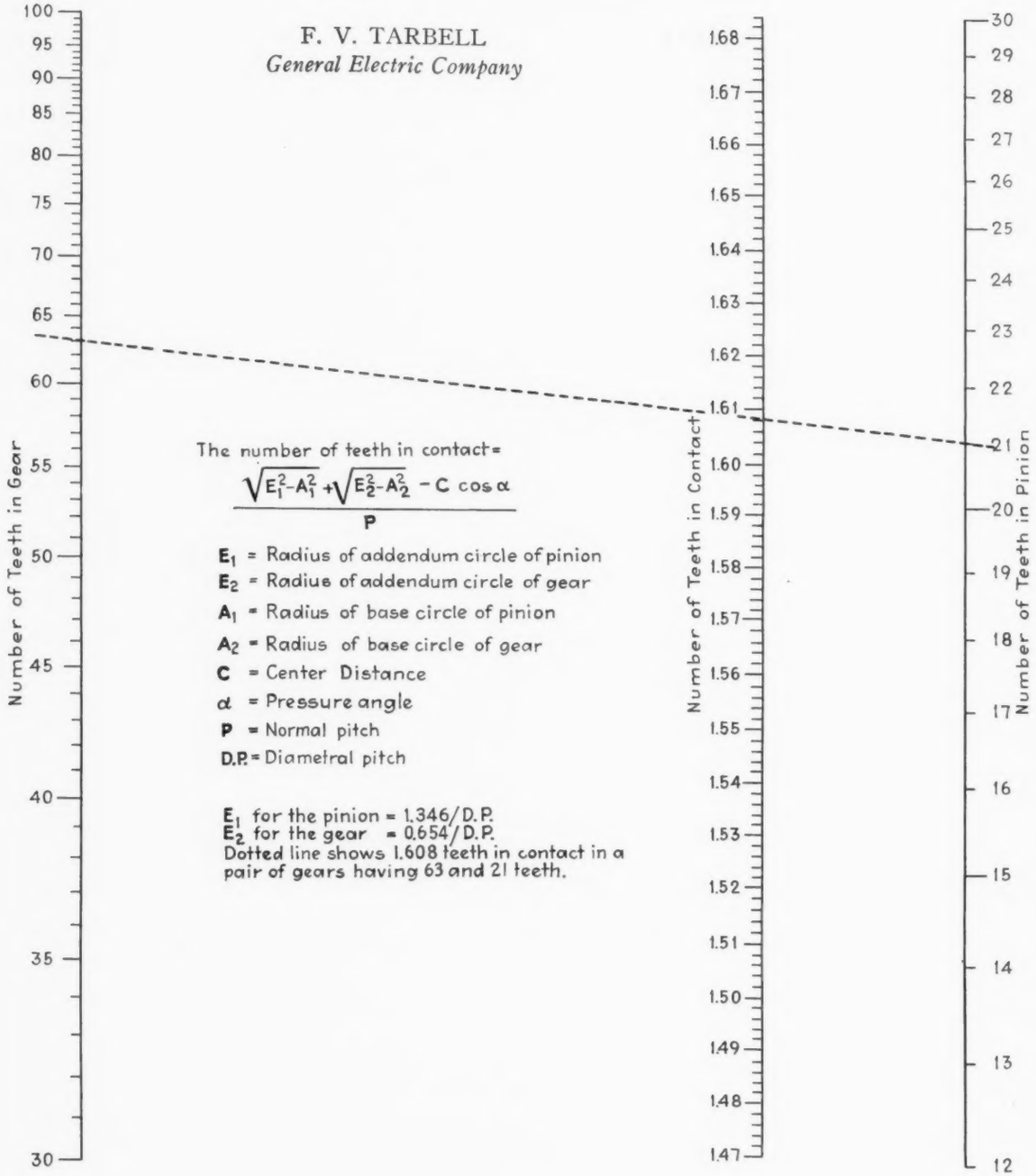
Number of Teeth in Contact

Chart for long addendum pinion teeth and short addendum gear teeth

F. V. TARBELL
General Electric Company



The number of teeth in contact =

$$\frac{\sqrt{E_1^2-A_1^2}+\sqrt{E_2^2-A_2^2}-C\cos\alpha}{P}$$

E_1 = Radius of addendum circle of pinion
E_2 = Radius of addendum circle of gear
A_1 = Radius of base circle of pinion
A_2 = Radius of base circle of gear
C = Center Distance
α = Pressure angle
P = Normal pitch
D.P. = Diametral pitch

E_1 for the pinion = 1.346/D.P.
E_2 for the gear = 0.654/D.P.
Dotted line shows 1.608 teeth in contact in a pair of gears having 63 and 21 teeth.

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